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Social acceptance and the translation of energy targets to local renewable energy developments

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Social Acceptance and the Translation of Energy Targets to Local Renewable Energy Developments

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Ph.D. Thesis

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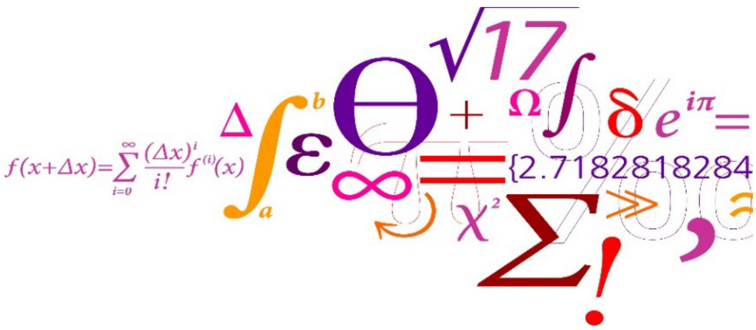

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Summary

This thesis focuses on the means of assessing the social acceptance of renewable energy (RE) technologies and seeks to establish how such assessment can be used to support the energy transition. Our current energy landscape is marked by a growing amount of distributed renewable power-producing sites, whose nature and numbers vary across countries and regions. Onshore wind energy in particular has seen a fast development in different European countries, thanks to a levelised-cost that is one of the lowest among renewable technologies. Yet, while this development is in line with EU and UN renewable energy-based strategy plans, the physicality of the turbines and the changes they have induced in landscapes have in some places been met with reactions of wariness and opposition. As a consequence, naming a lack of community acceptance as their main motive, the governments of Denmark and the UK have recently decided that a curb in the number of turbines is required.

In this over-arching context, the research field on social acceptance of technologies has mapped acceptance under three main dimensions: community, market and socio-political, with the intention to highlight how acceptance is shaped from numerous factors and actors. Ultimately, this knowledge should assist policy-makers in being more proactive in assessing potential showstoppers for the transition.

From the context of partial reversals on onshore wind power, this thesis identifies three issues linked to the relevance of top-down energy planning structures and policies in addressing community acceptance. The first paper addresses energy planning structures through a systematic review of peer-review energy modelling articles. It explores the relationship between energy models, the scales at which these tools are operated, and social aspects. Policy tools are investigated in the second and third papers. The second paper builds on the research on social acceptance and addresses the objective of the thesis to propose an innovative way to frame and address social and community acceptance. The paper applies an analytical framework to the National Renewable Energy Actions Plans (NREAP) of three wind-rich countries, Denmark, UK and Ireland, to explore the ways they articulate social acceptance. The framework was also designed to highlight cross-scalar dynamics that were not sufficiently explored by previous frameworks (Devine-Wright et al., 2017).

This analysis highlights a dearth of policy focus on community acceptance in the three cases. This finding is reinforced by the third paper which presents a statistical analysis of energy cooperative

trends in five European countries, and highlights how lack of policy supports is seeing cooperatives' numbers decline, in particular in Denmark. These findings prompt further interrogations on the means actually deployed to address the lacking community acceptance deplored by Denmark's and UK's governments, who have meanwhile decided to prioritise their offshore wind resources.

The Danish case is particularly interesting for the country's international image as a pioneer thanks to its grassroots-based shared wind sector and advanced policies. Denmark is the topic of the fourth paper, which presents an analysis of interviews conducted with actors of the Danish energy planning sector. This paper also coincides with the announcement of the coalition's new energy plan in June 2018. This final paper addresses in particular the human difficulties limiting progress for energy modelling to consider social aspects. This discussion leads towards the issue of collaborative work among researchers from different fields, still hindered by reported issues of "language barriers".

Thus, this thesis was designed to address community acceptance through the major steps that see national energy targets translated into local renewable energy developments. Within this broad framing, the thesis points to the current limitation of the European energy planning system, which in conclusion does not appear sufficiently equipped to preventively address possible issues linked to the community acceptance of additional distributed RE sites, still required to reach the set EU and national targets.

The thesis contributes to these broad problematics in two ways, by proposing a cross-scalar analytical framework destined to assess the comprehensiveness of policy sets with regards to the several components of social acceptance, and by addressing persistent collaboration difficulties among practitioners and researchers.

DANSK RÉSUMÉ

Denne afhandling fokuserer på de forskellige måder, hvorpå vi kan vurdere den sociale accept af vedvarende energiteknologier (RE) og søger at fastslå, hvordan en sådan vurdering kan bruges til at understøtte energiomlægningen. Vores nuværende energilandskab er præget af et stigende antal spredte vedvarende kraftproducerende anlæg, hvis art og tal varierer på tværs af lande og regioner. Energi fra især vindmøller på land er steget kraftigt i de forskellige europæiske lande takket være en pris, der er en af de laveste blandt vedvarende teknologier. Selvom denne udvikling er i overensstemmelse med EU's og FN's strategiplaner for vedvarende energi, er vindmøllerne og de ændringer, de har fremkaldt i landskaber, på nogle steder blevet mødt af skepsis og modstand. Med manglende accept i samfundet som hovedargument har regeringerne i Danmark og Storbritannien som følge heraf for nylig besluttet, at der er behov for en begrænsning af antallet af vindmøller.

Forskningsområdet, social accept af teknologier, beskriver accept ud fra tre hovedområder: samfundsmæssig, markedsbaseret og socialpolitisk med det formål at fremhæve, hvordan accept formes af mange faktorer og aktører. I sidste ende bør denne viden hjælpe politikere til at være mere proaktive i vurderingen af omlægningens potentielle showstoppere.

Denne afhandling identificerer tre spørgsmål i forbindelse med relevansen af top-down energiplanlægningstrukturer og –politikker, når det gælder håndtering af samfundets accept. Den første publikation omhandler energiplanlægningsstrukturer og er en systematisk gennemgang af peer-reviewed energimodelleringsartikler. Den undersøger forholdet mellem energimodeller, hvor og hvor meget disse værktøjer anvendes og sociale aspekter. Politiske virkemidler undersøges i anden og tredje publikation. Den anden publikation bygger på forskningen inden for social accept og adresserer formålet med afhandlingen, nemlig at foreslå en innovativ måde at formulere og forholde sig til social og samfundsmæssig accept på. Publikationen anvender en analytisk metode på de nationale handlingsplaner for vedvarende energi (NREAP), der gælder for de tre vindrige lande, Danmark, Storbritannien og Irland med det formål at undersøge, hvordan de adresserer social accept. Metoden blev også udviklet for at fremhæve tværgående samarbejde, som ikke blev tilstrækkeligt udforsket ved tidligere metoder (Devine-Wright et al., 2017a).

Denne analyse påpeger at der i de tre tilfælde (DK, UK and IRL) mangler politisk fokus på lokalsamfundets accept af vindmøller Denne opfattelse styrkes i den tredje publikation, der præsenterer en statistisk analyse af energikooperative tendenser i fem europæiske lande, og

fremhæver, hvordan manglende politisk støtte betyder et fald i antallet af vindmøllelaug, især i Danmark. Disse resultater stiller spørgsmålstegn ved den metode, der rent faktisk er benyttet til at adressere den manglende samfundsaccept, som beklages af Danmarks og Storbritanniens regeringer, der i mellemtiden har besluttet at prioritere deres offshore-vindressourcer.

Den danske sag er særligt interessant for landets internationale image som pioner takket være den græsrodsbaserede fælles vindsektor og innovative politikker. Danmark er emnet i den fjerde publikation, som præsenterer en analyse af interviews med aktører fra den danske energiplanlægningssektor. Denne publikation falder også sammen med meddelelsen om koalitionens nye energiplan i juni 2018. Publikationerne omhandler især de vanskeligheder, der begrænser udviklingen af energimodellering inden for sociale aspekter, nemlig spørgsmålet om samarbejde mellem forskere fra forskellige fagområder, der stadig er vanskeliggjort af problemer som "sprogbarrierer".

Således blev denne afhandling udarbejdet med henblik på at se på samfundets accept i forbindelse med de store tiltag, hvor nationale energimål omsættes til lokal udvikling af vedvarende energi. Inden for denne brede formulering påpeger afhandlingen, at det europæiske energiplanlægningssystem for nærværende ikke synes at være tilstrækkeligt rustet til forebygge mulige problemstillinger i forbindelse med samfundets accept af yderligere spredte vedvarende energianlæg, der stadig kræves for at nå de fastsatte EU- og nationale mål.

Afhandlingen bidrager til disse brede problemstillinger på to måder: ved at foreslå en tværgående analytisk metode med det formål at vurdere de politiske regulativer med hensyn til at inkludere de mange faktorer af social accept og ved at forholde sig til vedvarende samarbejdsvanskeligheder mellem udøvere og forskere.

ACKNOWLEDGEMENTS

On a personal basis, this thesis finds its roots in my previous activity as a junior developer of medium-scale wind turbine projects in Scotland. I was particularly proud of working in this field and addressing the issue of GHG emissions, albeit rather slowly with one 850kW turbine at a time. My initial motivation as a student in renewable energy engineering was the production of electricity, which we tend to waste and overuse, from a renewable source. Considering RE production in such engineering terms is very satisfying, it gives a sense of logic and completeness to one's professional activity. Yet, the experience of attempting to develop wind turbine projects in a human context revealed new levels of complexity for which scientific universal laws, equations and theorems could only provide very little answers. Thus was born the interest I hold for the challenge of actually implementing RE technology. This personal experience reflects on a small scale the obviousness and at the same time the sheer complexity of implementing comprehensive plans to reduce greenhouse gas (GHG) emissions at national and global scales.

Designing this PhD, conducting the research, writing the articles and finally the thesis has been a long and tedious but also impactful and thought-provoking process. I am very grateful to DTU for this opportunity to focus on such an interesting topic, as well as the institutions where I attended PhD courses and conferences. In particular I thank Queen's University Belfast where I conducted my research stay, and Cynthia Selin and Rafael Ramirez at Saïd Business School, Oxford University, for the opportunity to take part in the Oxford Scenario Programmes.

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I have a thought for the late Lauge Baungaard Rasmussen and remember our interesting conversation on scenario planning and his warning regarding how fast our thinking can become clustered and how thinking outside the box requires regular efforts.

I thank Dorrit Givskov and Jette Gents for translating the summary of this thesis into Danish, as well as their friendly support and kind words during the inevitable ups and downs: I am also grateful to the IDS group and Per Dannemand for their patience during my extension period.

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TABLE OF CONTENTS

"We cannot wait for governments to do it all. Globalization operates on Internet time. Governments tend to be slow moving by nature, because they have to build political support for every step."

Kofi Annan

Chapter 1

CONTEXT AND THEORIES

1.1 INTRODUCTION

As the Conference of the Parties (COP) meetings have demonstrated over the years, governments have to consider numerous factors when deciding to modify their means of producing and consuming energy. Despite climate scientists' urgency to switch to renewable sources, certain factors restrict countries to using traditional oil and gas systems. In 2015, at the 21st COP meeting, countries reached the first near-global agreement for collective action (UNFCCC, 2015). As a result, nearly all countries committed themselves to Intended Nationally Determined Contributions (INDC), which are the national objectives for curbing GHG emissions based on countries' capabilities (World Resources Institute, 2018).

Numerous factors shape energy systems and influence governmental decisions. Therefore, it is of great interest to be able to structure and map the key factors in order to prioritise the areas of society that require primary actions and policy adjustments to better support energy transition. The United Nations (UN) and European Union (EU) use techno-economic modelling tools, indicators and targets to track the evolution of various technologic and socio-economic areas. Similarly, research has also focused on those influencing factors and on producing comprehensive ways to gather those factors and map the national proclivity for supporting energy transition and RE development. Among those factors, social acceptance of renewable technologies is a conceptual indicator resulting from different levels of acceptance across society, such as financial sectors, manufacturing, regulatory authorities, citizens, R&D etc. Through this thesis set in an EU context, we will see that most of these influencing actors and factors shaping social acceptance are being assessed and, to some extent, addressed in official spheres, while this is not yet so evident for matters of community acceptance.

In the research arena, to address this topic of social acceptance, Wüstenhagen et al. (2007) proposed a mapping of "social acceptance of renewable energy innovation" derived from three dimensions of society: community, market, and socio-political. Sovacool and Lakshmi Ratan (2012) developed it further by characterising three factors for each dimension and applying the framework to wind and solar sectors in four case-study countries. Fournis and Fortin (2017) proposed a similar trilateral framework but based on geographical and political scales and the work of Szarka (2007) on the perceived acceptability of wind power in Europe. In terms of scale inclusion, Devine-Wright et al. (2017) called for a re-thinking of the general framework of social acceptance, towards a greater focus on "how each dimension inter-relates across different geographical scales (from macro to micro; international, national and local)". They added that "few empirical studies have encompassed more than one of the three aspects in their respective analytical frames" (Devine-Wright et al., 2017).

This thesis responds partly to this call for a development towards the inclusion of cross-scalar dynamics. It does so by framing the thesis within what I label the 'translational process', which conceptually covers the steps required for the translation of UN and EU global targets into the construction of RE projects at the local scale. Within this framing and the several geographical scales it covers, the thesis is able to explore the theme of social acceptance at those scales while also maintaining a cross-scalar approach by having to reflect this inclusive broader framing. In Chapter 1, after first describing the current context shaped by these UNFCCC and EU decarbonisation targets, I detail the steps that constitute the translational process. Reflecting first on what constitutes this conceptual process was important in an attempt to step beyond the paradigms operating at each step and geographical scale. Thus, I attempt to maintain a more comprehensive view in the sense that policies and actions have effects at all scales of society, even if they were designed for a particular scale. Likewise, cross-scalar dynamics will affect the outcomes of policies in ways that might not have been foreseen if the policies were designed for actors at one targeted scale.

Chapter 1 examines the European context to identify three main issues that will be addressed through the thesis: (1) the relevance of top-down energy planning systems, (2) the policies and measures implemented to address issues of public acceptance of technologies, and (3) the research on social acceptance and the call for the inclusion of cross-scalar dynamics, as discussed above. These issues are rephrased into a main research question, four sub-questions and associated theoretical backgrounds that guide the thesis. Considering the issues identified and the framing selected, the goal is to widen the study scope so as to point to cross-disciplinary and cross-scalar dynamics that might not be addressed in more narrowly framed studies. Thus, the objective is to propose an innovative way to frame and address social acceptance that both reflects and adapts to its inner dynamics.

This article-based thesis contains four papers, which are presented in Chapters 2 to 5. The papers are independent studies aimed at different journals; however, several key themes unite the papers so that they provide information and findings to support reflection on the issues identified from the energy context and present novel elements that contribute to the overall research on social acceptance. A first theme common to the papers is the matter of scale and what are considered norms at the various scales of energy governance. A second unifying theme is that of social aspects of transition and how social dynamics and their potential effects on energy plans are considered within the current energy planning paradigms. The third theme is that of inter-disciplinary perspectives and how addressing the previous two themes requires a rethink of current planning and research clusters.

Following the steps that constitute the translational process, Chapter 2 first discusses the evolving characteristics of energy-modelling studies. The empirical work comprises a systematic review of 297 peer-reviewed articles presenting energy-modelling work among the COP 15 in 2009 and the COP 21 in 2015. Initially drawing from previous works from modellers (Connolly et al., 2010; Gargiulo and Gallachóir, 2013; Loulou and Labriet, 2008; Pfenninger et al., 2014), this review then provides some initial points of reflection on the implication of the ever-increasing role given to modelling tools, such as testing future policies, despite their limitations for modelling human behaviours.

In Chapter 3, we look at the policies proposed by Denmark, Ireland and the UK as part of their National Renewable Energy Action Plans (NREAPs) submitted in response to the EU's Renewable Energy Directive in 2009. Drawing from the literature on social acceptance mentioned earlier in this introduction (Devine-Wright et al., 2017; Fournis and Fortin, 2017; Sovacool and Lakshmi Ratan, 2012; Wüstenhagen et al., 2007), we develop a cross-scalar framework for the study of social acceptance, and thus explore how it is articulated within the three policy sets. We run the study on those three EU countries because they provide a common EU policy frame and, more importantly, all benefit from high wind resources – a geographical fact that has impacted the evolution of their national energy systems and policies.

Chapter 4 presents statistical evidence of the role that energy cooperatives have played in opening renewable energy sectors in Denmark, the UK, Germany and Austria. As such, they are enabling actors of energy transition in Europe, but they are now facing strong competition from corporate actors, as well as diminutions of their financial support schemes, and as a consequence, their numbers are fast decreasing. We discuss the need for a more systematic recording of their contribution as part of their national energy systems and the overall transition.

Chapter 5 draws on interviews with actors of the Danish energy system, such as modellers, local developers and social scientists, to explore the dynamics that occur among those actors working at different scales of the process. We reflect on the differences and crossovers expressed during the interviews to develop on how these current dynamics, when problematic, might affect the transition and how they can be addressed. This chapter draws from the literature on the social worlds framework (Clarke and Star, 2008) and on network theories (Burt, 1992; Long et al., 2013).

Drawing from these combined findings, Chapter 6 presents an overall discussion on the research question, highlights issues identified from the European energy and policy contexts, and proposes some suggestions for future development and research.

1.2 Context

1.2.1 Climate change and global GHG targets

The delicate climate that surrounds us and allows us to live on this planet, considered a given until a few decades ago, has now become the topic of heated debate regarding how it is affected by our recently acquired lifestyle and quest for comfort. While some continue to argue, the vast scientific majority has shifted the debate towards how to limit the impacts of global warming, which we already suffer from, and attempt to curb the damage to an increase of 2 °C (already colossal given such a short time-span) or even 1.5 °C (IPCC, 2017). The strategy to do so relies mostly on modelling energy scenarios aimed at a global reduction of CO_2 and other GHG (greenhouse gas) emissions from human activities, which are responsible for tilting the natural balance between production and absorption of those gases and have the property of trapping heat and, when concentrations are too high, creating a greenhouse effect.

While this plan seems simple enough, modifying human activities at the global level is no easy task, as such imposed changes affect a multitude of actors, financial interests, technologies and rationalities in a multitude of cultures and varying approaches to nature and the environment. Therefore, the straightforward scientific instruction to urgently and globally reduce our GHG-producing activities needs, firstly, to be translated into an objective that seems applicable at the national level. This first translation has been the topic of the UNFCCC (United Nations Framework Convention on Climate Change) in the form of yearly COP (Conference of the Parties) gatherings – from COP3 in Kyoto, Japan, in 1997 to the upcoming COP24 in Katowice, Poland, in December 2018. COP21 in Paris was the first iteration of the conference that saw almost all countries agreeing to the objectives suggested by the UNFCCC in 2015. Although Nicaragua and Syria initially abstained, it was largely deemed a success in terms of global approval due to the vast majority of signatories from both developed and developing countries. However, in 2018, the newly appointed US government decided to withdraw from the agreement, allegedly to safeguard its economic interests. Nicaragua and Syria have since joined the agreement, leaving the US, the second largest emitter of GHG emissions after China, as the sole country rejecting it.

The agreement itself requires each nation to set its own target, or Nationally Determined Contribution, to reduce (or limit) its GHG emissions, but it does not plan any enforcement mechanisms or fixed target dates. Thus, the success of the agreement relies on nations fulfilling, in principle, the ideal to which they became signatories. This non-binding nature of the agreement and the fact that COP21 was the first of its kind to be considered an international success illustrate how, despite the urgency of the matter, the downscale translation of such a global necessity to national realities is not a straightforward process. The increasing frequency at which we witness – or, for some, merely survive – the dramatic consequences, both in scale and effect, of global warming has led activists and concerned citizens to question why the decarbonisation process is not compulsory and simply prioritised above all other interests, and in particular why detrimental sectors and industries are allowed to remain active.

In a democratic context, accelerating such a broad transition process requires a deep understanding of its components to be able to propose appropriate innovations to current policies that would not subsequently face unmanageable levels of opposition. Such a political setting leads back to the importance of social acceptance and being able to assess its effects, proactively and comprehensively, on the vast plurality of actors, scales and interactions that make the development of such an understanding an arduous task.

1.2.2 EU targets

Within the UNFCCC, the EU has also been active in shaping its vision and plans to curb GHG emissions. In 2009, the EU announced the implementation of the RE (Renewable Energy) Directive, which sets a common target of 20% of overall energy and 10% of transport energy produced by RE sources by 2020 (Council of the European Union, 2009a). The translation to national level takes the form of individual targets based on each Member State's potential for RE development. In this case, the targets are binding, although no clear frames have been communicated regarding the level of fines to be imposed on unsuccessful or uncooperative countries.

Subsequently, in 2010, Member States produced and revealed a National Renewable Energy Action Plan (NREAP) designed for each country to reach its own target in terms of RE electricity and heat production. The basic requirements set by the Directive asked that NREAP presented the set of policies, current and upcoming, designed by each government to generate the set increase of RE development activities, as well as the capacity forecasted for each type of RE technology for electricity, heating and cooling, and transport. Each Member State was free to prioritise the types of technologies they deemed best adapted to their current energy systems and development scenarios.

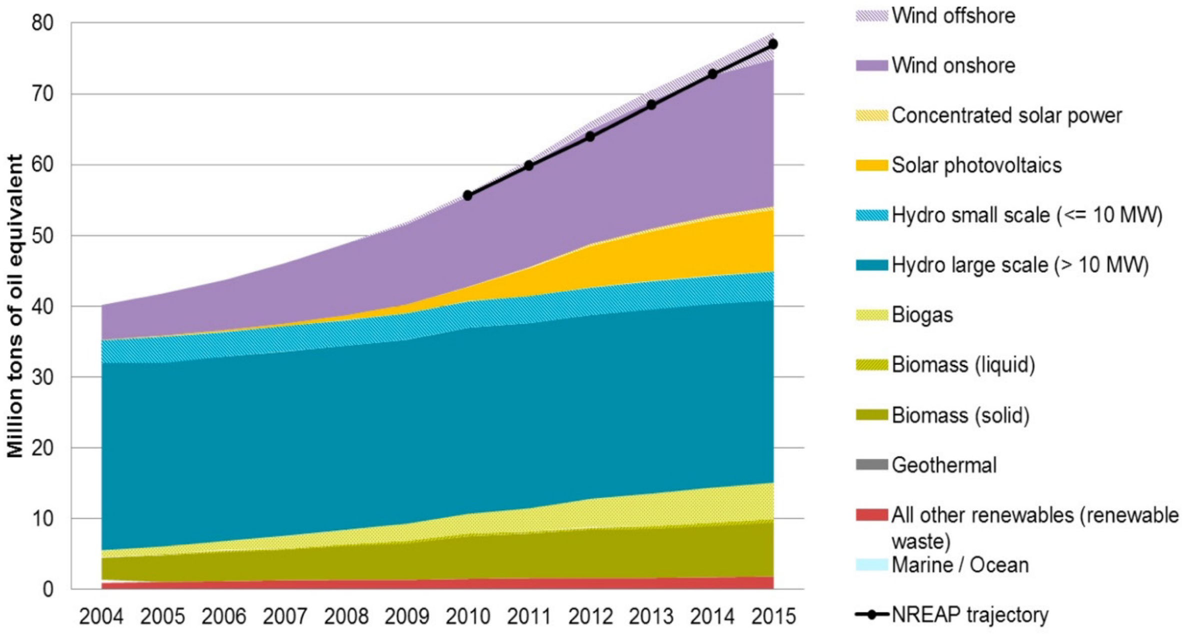

Figure 1 EU-28 renewable electricity production by source (source: EUROSTAT, Öko.Institut, (European Commission, 2017)*)*

Member States produce bi-annual progress reports with updates on the policies and forecasts declared in the initial NREAP. The latest common progress report aggregated by the EU Commission in 2015 revealed that NREAP trajectories were on track for electricity and heating and cooling, but transitions in the transport sector were lagging behind (European Commission, 2017). The RE contribution for heating and cooling was above the aggregated trajectory, and the largest contributor was solid biomass (82%) followed by heat pumps (9%). Overall, RE heating and cooling represented the largest RE production above 90Mto$_e$, followed by RE electricity, with 78Mto$_e$ and RE transport, with 16Mto$_e$.

Figure 1 shows the overall contribution and progress of each RE technology up until 2015. Besides the steady largest contribution of large-scale hydro (38%), onshore wind was the second main producer of RE electricity (30%), followed by biomass (19%), solar PV (11%) and offshore wind (6%). What is not directly obvious through those figures is the fact that onshore wind, solar PV and biomass are decentralised or distributed generation, and therefore such progress curves illustrate that a deeper change has occurred in the way we produce electricity.

The shares of onshore wind, solar PV and biomass, combined with their rapid growth (since 2010, onshore wind capacity has doubled and solar PV has more than quadrupled) but low power density per surface unit (Smil, 2010), illustrate the ongoing transition from centralised energy systems operating on oil and gas power stations, to grids where such stations are increasingly complemented by RE energy-producing units distributed across locations adapted by planning authorities (Bridge et al., 2013).

The IEA (International Energy Agency) defines decentralised power as "*a system of distributed-energy resources connected to a distribution network*", where distributed energy resources refer to distributed or dispersed generation plus demand-side measures. They directly link the development of decentralised generation with the action on climate change, listing it as one of the five major impacting factors besides developments in distributed generation technologies, constraints on the construction of new transmission lines, increased customer demand for highly reliable electricity, and electricity market liberalisation (International Energy Agency, 2002). The spatial characteristics of decentralised generation means that, compared to larger centralised power-producing plants (50 MW+), decisions on the feasibility of each decentralised plant project are made more frequently and at the local scale by spatial planning services.

1.2.3 The role of spatial planning departments

Beside the technical definition and framing, the rapid increase in decentralised energy has had a significant impact on the landscape and, by extension, populations, prompting the characterisation of the transition also in a geographical context. As such, Bridge et al. (2013) explore how "*a geographical perspective on transition* [to RE in general] *foregrounds questions about spatial difference (and the co-existence of multiple transition pathways and possibilities); relations of position and connection (as illustrated, for example, by the simultaneous processes of integration and fragmentation associated with new energy infrastructure); and spatial configuration and scales of organisation (for example, the durability of national energy systems)*" (Bridge et al., 2013). Such questions, which associate global and EU RE targets to social dynamics that are more complex than initially framed by the RE Directive, relate to what Walker and Cass (2007) coin "*hypersizeability*" (Walker and Cass, 2007). Through the term, they point out the distinctive characteristics of RE onshore wind, solar PV and biomass to be implemented at widely different sizes "*in terms of both physical form and energy generating capacity"*. In consequence, those technologies have "*different relational qualities of physical presence, connection to other physical infrastructure (buildings in particular), degrees of mobility and potential for environmental impact and disturbance"* (Walker and Cass, 2007). In this context of *hypersizeability,* the fast development of onshore wind as a major contributor to the EU's successful progress towards its 2020 RE electricity targets (as seen in Figure 1) has led to divergence within public opinion to a much wider extent than for any other RE technology (Ellis and Ferraro, 2016; Haggett, 2010). The significant variation in the sizes of devices leads to varying levels of environmental impacts, and devices are also associated with varying forms of ownership and financial support from public funding (Walker, 2008). The resulting uncertainty as to what each proposal entails has led to important variations in the nature of social relations, including feelings of mistrust and anxiety towards new proposals (Bell et al., 2005; Devine-Wright, 2013a; Ellis and Ferraro, 2016).

In particular, the favourable niche in which onshore wind power found itself in the past decades in several EU countries (Verbong and Geels, 2007), both in terms of socio-political support, in the form of advantageous feed-in tariffs and tax-exemption policies, and in terms of market support[1] with active investment and R&D activity, resulted in a decisive cost decrease (IRENA, 2018, p. 94). Yet, the broad range of turbine sizes and ownership means that an individual could, in principle, support wind power, especially when associated with small to medium-scale cooperatives (Warren and McFadyen, 2010), while also being against its large-scale development on nearby uplands (Walker and Cass, 2007; Wolsink, 2007a). Thus, a paradox situation arose whereby wind power was presented by national surveys as widely supported by populations while also creating sharp antagonism in localised dynamics revolving around new project proposals.

For each Member State, appraising such dynamics and general technical and environmental feasibility is generally incumbent upon local spatial planning departments (often up to a certain power capacity, after which governments become the deciding authority [UK Department for Communities and Local Government, 2013]). Because of its strategic and deciding role, spatial planning authorities have attracted greater focus from the EU Commission and, by extension, from Member States following EU guidelines as part of the RE Directive. As such, one of the minimum requirements to be presented within each NREAP was the detailing of specific support policies and measures to fulfil the requirements of *Article 13 – Administrative procedures, regulations and codes*, which requires a streamlining of administrative procedures. In particular, it recommended: "*simplified and less burdensome authorisation procedures, including through simple notification if allowed by the applicable regulatory framework, are established for smaller projects and for decentralised devices for producing energy from renewable sources, where appropriate*" (Council of the European Union, 2009a). In response, most NREAPs include policies aiming to simplify spatial planning processes and make them further adapted to the nature of each RE technology. For example, Ireland's NREAP announced, somewhat broadly: "*The Bill provides for changes to the planning system and proposed changes will have certain implications for the renewable energy sector*" (*National renewable energy action plan Ireland*, 2010).

[1] Referring to the dimensions of social acceptance by Wüstenhagen et al. (2007) described in section 1.3.2.2

This focus from the EU Commission corresponds to a common discourse during the previous decade, embraced by varied stakeholders, of "planning barriers" limiting RE development, and onshore wind in particular (Ellis et al., 2009). This discourse appeared in a context of favourable feed-in tariffs for RE power in several EU countries, and developers were eager to gain planning authorisation quickly to be able to secure additional sites and maintain investors' interest. Writing about the UK context, Ellis et al. (2009) and Cowell and Owens (2006) argue that the discourse was misplaced and the quest for sustainability had been used to justify a pro-market stance through planning: "*such debates tend to over-emphasise planning as an obstacle to the investment-led deployment of renewable energy, and fail to appreciate its potential role as practically the only mechanism for mediating environmental disputes in a democratic arena*" (Ellis et al., 2009). Indeed, during that period in the UK a large gain could be made from feed-in tariffs for a single onshore wind turbine below 1 MW (Ofgem, 2018), which prompted numerous planning applications for single turbines of such capacity, displaying a height to tip that could reach 100–120 m. Developers were prompt in seeing the advantage of such a scheme, and planning authorities received and dealt with a sharp increase in project proposals for such turbine types, whose heights required detailed environmental and technical impact assessments. Meanwhile, all planning proposals had to be made available online so that local citizens would be able to follow proposal activities and lodge formal objections or support if they so wished. The delays that sometimes occurred in making final planning decisions for each single proposal irritated certain actors in the wind-farm development sector, and this contributed to the appearance of the "planning barriers" discourse.

This example of the British planning authorities illustrates their role in actively translating targets and policies, which in some cases are (overly) influenced by market objectives (Cowell and Owens, 2006; Ellis et al., 2009), into meaningful phenomena actually felt among local populations, as opposed to intangible energy targets. Seen in that light, Ellis et al. argue that planning has a much greater role to play towards social acceptance of RE, and the focus on planning barriers has led to the evolving research on social acceptance being overlooked: "*planning for wind energy could then become a critical arena of policy learning for wider debates on social acceptance, through which democratic legitimacy and public understanding are nurtured as part of a more sustainable future*". Indeed, the proximity of a planning process to a population and knowledge of local dynamics could be used as a powerful advantage for "*encouraging deliberative processes*" and strengthening the population's understanding of what is at stake and what positive outcomes the targets, policies and, by extension, local RE projects are aiming to achieve (Ellis et al., 2009).

1.2.4 Overall implementation process

Figure 2 summarises the previous three sections from global targets to local spatial planning in an EU context. It schematises how the international community has debated the dangers of climate change and decided almost unanimously in 2014 to act by reducing GHG emissions from human activities, although with no set targets. This decision is echoed more practically by the EU's 2009 RE Directive, which set common RE targets of a 20% share of overall energy and 10% in the transport sector by 2020. This is to be achieved by Member States reaching binding individual targets following their own NREAPs, which present modelled capacity forecasts and sets of policies to support the objective. Thus, Member States have been actively setting and readjusting energy, financial and planning policies to support the development of RE technologies. The feasibility and impacts of RE project proposals, apart from a few very large projects, are assessed through local planning, which also has the role of collecting objections and support from citizens for a given project. Onshore wind power underwent a rapid increase in several Member States in the 1990s and is currently the second main contributor to the EU RE electricity pool, behind large-scale hydro (which has no current prospect for further increase) and ahead of biomass (the main contributor if also including RE heating and cooling) and solar PV. The transition and rapid increase in decentralised RE power sites has been met with varied levels of social acceptance, and in particular onshore wind, due to its rapid and visible expansion in several Member States.

As mentioned in the introduction, an overarching theme of this thesis is that of scales of energy governance, and some attention was given to not creating clustered analysis that might only apply to a particular level. Some additional inspiration for this inclusive approach is further discussed in section 1.3.3. Consequently, in an attempt to maintain this multi-scalar inclusion throughout the thesis and analysis, this conceptual representation of a translational process is used to frame the thesis. This framing is further discussed in the section on the study design and particularly in section 1.4.1.

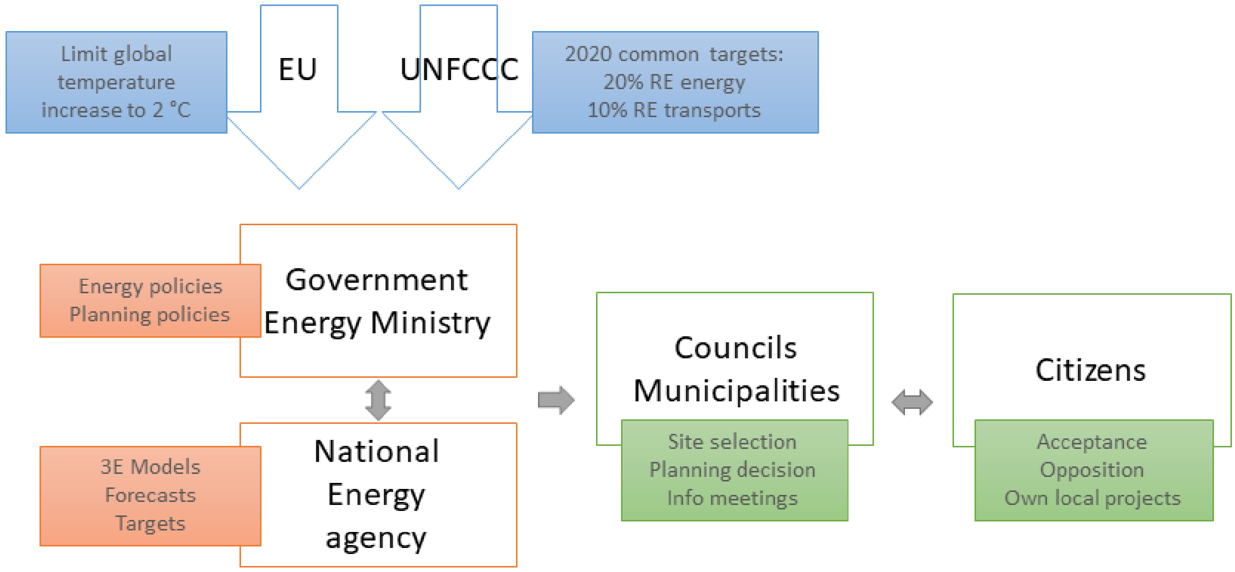

Figure 2 Representation of the major steps, actors and rationalities of the conceptual translational process in the EU context

1.2.5 "Implementation deficits" within the translational process

Considering the numerous actors and dynamics that form the translational process, there is a similarly high number of risks of dysfunctions or disturbances across the process. Working in the policy context, Hogwood and Gunn (1993) labelled such potential dysfunctions as "implementation deficits" (Hogwood and Gunn, 1993). Below, I discuss potential deficits from the political sphere and the community level of energy projects. This section is meant to illustrate some potential implementation deficits that are further discussed as part of the thesis, but it is by no means an exhaustive list of such possible disturbances.

1.2.5.1 Political

A potential disturbance at a high level of governance, illustrated by recent examples, is that of political stand-off. While the individual national targets set by the EU are binding, the incurred fines in cases of non-compliance have not been precisely set by the Directive, which is a practice in line with the preferred 'dialogue approach' the EU traditionally adopts. In such circumstances, the position and commitment of past, current and future governments regarding sustainability play an important role towards achieving a country's target. In this context of political path dependency, Alkin and Urpelainen (2013) measured the influence of political strategy on policy choices and found that levels of regulation of decarbonisation measures tend to be applied strategically by governments depending on external pressure and their initial commitment to sustainable energies.

"*We find that political competition modifies the effect of path dependence on policy and outcomes. Specifically, while 'green' governments can use positive reinforcement mechanisms to lock in policy commitments (by creating green constituencies), 'brown' governments strategically underprovide public support for renewable energy (to avoid creating green constituencies). […] Failure to account for strategy is a major obstacle to understanding both path dependence and domestic responses to international pressure*" (Aklin and Urpelainen, 2013).

Energy systems are shaped by their path dependency (Verbong and Geels, 2010), which Martin and Sunley (2006) defined as a process or system "*whose outcome evolves as a consequence of the process's or system's own history*" (Martin and Sunley, 2006), and that Pierson (2000) conceptualised into a "*social process grounded in a dynamic of 'increasing returns'*", where 'increasing returns' are defined as self-reinforcing or positive feedback (Pierson, 2000). Thus, adding to Pierson's view of a process driven by the likeliness of a resulting profit, Alkin and Uperlainen's analysis points out how the likeliness for international pressure (such as the EU Directive) to actually influence a national energy system still primarily depend on the government's strategy in the face of its current political competition and international relationships.

This is a significant limitation to the vision of a union of Member States – either the EU or UNFCCC – acting together towards a shared ideal (or least damaging) outcome, and recent mediatised examples illustrate this limitation, when political strategies challenge international plans born of scientific urgency. In 2017, President Trump withdrew the USA, the second largest emitter of GHGs, from the list of signatories of the COP21, allegedly to protect US financial interests. In August 2018, Prime Minister Turnbull of Australia contemplated scrapping climate change actions when challenged by a front of dissident politicians, allegedly lobbied by actors of the coal industry; he eventually resigned (Hutchens, 2018). Within the EU, in 2015, citing a lack of public support for onshore wind power, the British Conservative Party, at that time running for re-election, declared its intention to halt any plans for additional onshore wind power, despite being part of the ongoing EU Directive plans for 2020 targets (Department of Energy and Climate Change, 2009). Finally, this year, Denmark also cited rejection of onshore wind power by local communities and loss of property values as the main reasons for its plan to scrap numerous onshore turbines. The move is associated with the launch of a bidding system[2] for onshore and offshore wind and solar PV energy, without a clear adaptation of the bidding rules for local cooperative projects, thus prioritising large corporate actors of the energy sector (Danish Coalition, 2018).

[2] EU-wide transition to a bidding process to bring down the costs of renewable energies. However, the EU Commission suggested that countries include exceptions for smaller-scale projects, such as typical cooperative project size. Denmark opted not to include such exceptions (Danish Coalition, 2018).

The last two examples for the UK and Denmark show that matters of community opposition towards renewable energy projects, often towards onshore wind power, have reached the political spheres. We can only speculate whether those decisions come from a genuine concern for citizens' well-being, or because they fit a broader agenda, but the partial rejection of a technology with some of the lowest levelised costs and life-cycle assessments calls for further scrutiny of the ways in which community acceptance is addressed, as we are no nearer to solving the danger that is climate change.

1.2.5.2 Community Acceptance

This problematic of wind power projects eliciting negative reactions among local populations has been widely researched (Haggett, 2010; Walker, 1995; Wolsink, 1994), and in that sense, the technology stands apart from other RE technologies, which have so far prompted a less fervent reaction. Such opposition has been linked to different possible causes; the NIMBY explanation, the idea that people support wind power except when it is near their home (Gipe, 1995), gained a certain popularity (maybe partly for its amusing and memorisable acronym) but has since been judged over-simplistic and even potentially harmful, for it impedes our understanding of more complex and sensitive dynamics (Wolsink, 2006).

Thus, some have argued that the discourses associated with public opposition to wind farms have been generally oversimplified by researchers, who have ended up framing their research objectives from common assumptions rather than data. Aitken (2010) lists five common standpoints that she considers should be presented clearly as assumptions: "*(1) The majority of the public supports wind power. (2) Opposition to wind power is therefore deviant. (3) Opponents are ignorant or misinformed. (4) The reason for understanding opposition is to overcome it. (5) Trust is key*" (Aitken, 2010). She argues that objectors are often very knowledgeable of wind power specificities and energy in general, and therefore, dismissing their claims as ignorance and narrow-mindedness misses the point of social research entirely. She adds: "*Public attitudes and responses to wind power should not be examined in order to mitigate potential future opposition, but rather in order to understand the social context of renewable energy*" (Aitken, 2010). Earlier, in 2007, Ellis et al. had already pointed to the "unreflectively pro-wind" and "unreflectively positivist" positioning of the literature on community acceptance at that point (Ellis et al., 2007).

Introduced as more nuanced than the NIMBY assessment of local opposition to wind turbines, the work on place attachment aimed to re-associate these considerations with their local contexts. The environmental social scientist Patrick Devine-Wright (2013) writes of place attachment: "*From this perspective, local opposition is reconceived as a form of place-protective action, arising when technology projects* *disrupt pre-existing place attachments and threaten place-related identity processes*" (Devine-Wright, 2013b). Unlike NIMBY, this approach acknowledges that a different rationale exists for each opinion. This rationale evolves from the connection between people and their environment, which also participates in identity-making processes (Devine-Wright and Howes, 2010). Those are strong emotions, which can logically lead to strong reactions if the induced change – such as the erection of a wind farm beside one's home – and the way it is introduced do not respect this individuality. Other potential causes for opposition include the physical disturbances produced by poorly sited turbines (Pedersen and Persson Waye, 2004), the moral opposition to 'not local' and/or corporate companies earning vast benefits from windfarms but returning limited amounts (at best) to the populations impacted (Walker and Cass, 2010), or, in line with the previous two causes, the perceived lack of procedural justice felt by local populations during planning and decision processes (Wolsink, 2007b).

Following this research, different ways have been proposed to respond to such movements of local opposition. They typically include earlier involvement of local populations into the siting and planning processes (Bishop and Stock, 2010; McLaren Loring, 2007; Nadaï and van der Horst, 2010; Wolsink, 2013), more communication between the different actors – populations, developers, authorities – and open decision-making processes (Wolsink, 2007b). Indeed, as the research itself evolved from an allegedly partially biased standpoint towards a less two-sided representation of the local problematics occurring during RE developments, the suggested responses also become more inclusive of the various actors. Therefore, while these analyses are initially developed from case studies, often on a single technology, their recognition and implementation within energy policies and dynamics at broader scales are now widely recommended, so as to frame them within the wider energy context and the plurality of technologies that constitute energy networks (Barry and Ellis, 2010; Ellis et al., 2009; Fast and Mabee, 2015). Failure of research to thus evolve, and instead remain mostly focused on case studies centred on one or two technologies, could lead to it becoming irrelevant.

1.3 Research questions and Theoretical context

1.3.1 Identified issues, research objectives and questions

From the broad context depicted in section 1.2, I identify several main issues and research gaps. Discussed in section 1.2.5.1, the partial dismissal of a beneficial[3] technology on the grounds of lacking public or community acceptance suggests two main questions. The first issue concerns the

[3] In terms of effects on global GHG emissions

relevance of top-down energy governance and planning structures within European contexts. Studies cited in section 1.3.2.1, such as (Gargiulo and Gallachóir, 2013; Nguene et al., 2011; Ribeiro et al., 2011) have been exploring the need and/or means for the inclusion of social aspects into power system modelling but have not met definitive results yet concerning modelling tools used at the national decision-making scale.

The second issue concerns the measures and policies, as well as their reach and associated resources, which are in effect tried and implemented to tackle this lack of public support. Energy policies are often studied within a national framing, such limitation makes sense as it allows for a deeper understanding of the context surrounding the policies. However, considering the rapid evolution of the governance role given to the EU during the past decade (the EU Energy Directive was launched in 2009), and the common policy structures it implemented to reach EU energy targets, it is also necessary to explore inter-country policy behaviours and outcomes in this recent governance context.

Discussed in section 1.2.5.2, the description of the research on community acceptance illustrates how this body of research tends to be conducted at the community level, but there remains a lack of research on interactions between dynamics at the different scales of the energy system. This particular point reflects the motivations behind the call for further research on cross-scalar interactions formulated by Devine-Wright et al. (2017b), as discussed in section 1.3.2.2.

Thus the issues identified can be summarised as:

- the need and means for the inclusion of social aspects into power system modelling at the national decision-making scale (Gargiulo and Gallachóir, 2013; Nguene et al., 2011; Ribeiro et al., 2011)
- the reach and associated resources of the measures and policies implemented to tackle a lack of public support
- the lack of research on interactions between dynamics at the different scales of the energy system (Devine-Wright et al., 2017)

Reacting to these three key issues, to the overall context and finally to the main themes of scales and inter-disciplinarity (introduced in section 1.1), the overarching purpose of this thesis is to take a descriptive approach to examine the dimensions commonly associated with shaping social acceptance, community, market and socio-political factors, albeit in a broader context than often studied. By taking a figurative step back, the goal is to widen the scope of study framing so as to highlight cross-disciplinary and cross-scalar dynamics, points of friction and crossovers that might not be noticeable in more narrowly framed studies. The objective is thus to propose an innovative way to frame and address social acceptance that both reflects and adapts to its inner dynamics. For that purpose, the thesis proposes the following main research question:

How can social acceptance of renewable energies be framed and addressed for community acceptance to be appropriately considered within future energy plans?

To gather some elements to answer this question, the issues identified above were rephrased and adapted into the four following research sub-questions:

- How has the practice of energy modelling evolved between COP15 and COP21, and how does it relate to social acceptance? (Explored in Chapter 2)
- How was social acceptance articulated in the NREAP energy policies of three wind-rich EU countries: Denmark, Ireland and the UK? (Explored in Chapter 3)
- How are the numbers of energy cooperatives evolving in European countries, and what does this evolution mean for the role that energy cooperatives have been playing in energy transition? (Explored in Chapter 4)
- By exploring how the differing actors frame the issue of social acceptance of RETs and wind projects, we aim to identify how the framings differ, thereby revealing the ways in which they overlap. In which ways can the differing perspectives of the various actor groups be reconciled and even enhanced? (Explored in Chapter 5)

1.3.2 Theoretical context of the thesis

Before these four analytical chapters, I detail below the theories and practices associated with energy transition and social acceptance, which will support these articles, before presenting, in section 1.4 the overall study design and the four chapters in more detail.

While there are a range of theoretical frameworks for exploring the type of transformations change required by energy transitions (e.g. (Markard et al., 2012; Verbong and Geels, 2010)), this thesis focusses on the models and tools used in policy making and therefore is directed at the operational rather than conceptual level.

1.3.2.1 Energy Modelling

In the article presented in Chapter 2, we reflect on the recent evolution of energy modelling in the context of social acceptance. Back in the 1970s, the early instalments of energy modelling resulted from linear programming developed during the Second World War and were primarily concerned with production, demand and the cost-optimisation of energy sectors. In the 1980s, due to increasing public concern about the environmental impacts of energy production, modellers began to include aspects such as greenhouse gas emissions (Ribeiro et al., 2013). Since then, numerous models have been developed with an increasingly stronger focus on the ability to comprehensively inform climate policies and maintain financial relevance.

Labelled ‘energy scenarios’, ‘roadmaps’, or ‘strategy plans’, these long-term transition plans project energy use over several decades: often until 2050 and beyond. As discussed in sections 1.2.1and 1.2.2, such plans have become reified through processes such as the United Nations Framework Conference on Climate Change (UNFCCC) Conference of the Parties (COP), particularly COP21 in Paris (December 2015), where an emerging global consensus further coalesced on a response to climate change (UNFCCC, 2015), although still based on “common but differentiated responsibilities and respective capabilities, in the light of different national circumstances” (UNFCCC – Conference of the Parties, 2015). The EU 2009 Directive requirements for Member States to agree to binding renewable energy targets of 20% (Council of the European Union, 2009b) and produce National Renewable Energy Action Plans (NREAPs) also come with conditions of standardised calculations among Member States that require the use of models.

The most widely used techno-economic energy model, TIMES, is an energy model generator rather than an end-user energy model. It generates technology-rich, long-term optimisation models that combine a wide array of data to provide an optimal energy mix capable of covering a given demand at a given point in time for the minimal cost. Built in or externally provided by the modeller on a case-by-case basis, the data cover numerous parameters (e.g., energy costs; the costs of new devices, plants and refurbishment; their performances; imports/exports; energy incentives; and good consumption). TIMES is provided by the International Energy Agency (IEA). Its two main applications are the combined Energy Technology System Analysis Program (ETSAP)-TIMES Integrated Assessment Model (TIAM) and the Pan-European TIMES (PET) model, which is a multi-regional partial equilibrium model of Europe and is divided into 36 regions. TIMES can also generate models for individual countries, such as the Irish version of TIMES (Gargiulo and Gallachóir, 2013), and as such has been adapted to many countries’ energy systems. TIMES is free of charge; however, the shells or modelling language and solver must be purchased, with costs depending on the future user’s location (OECD or non-OECD country), the nature of its modelling activity, and its affiliation to ETSAP (ETSAP, 2013).

Another example of a popular model is LEAP (i.e., Long-range Energy Alternatives Planning), developed by the Stockholm Environment Institute. Its main purpose is to analyse and simulate the national energy sector, but it can also be used on other scales, depending on data availability. Students, academic organisations, NGOs and governments of developing countries can access LEAP for free. LEAP is designed to support different modelling technologies on the demand and supply sides. It recently added an optimisation function to its traditional simulation use, thus allowing the testing of least-cost energy systems and policies. This tool is intended for medium- to long-term modelling (usually 20 to 50 years) with a one-year time step. Its developers promote LEAP for its low initial data requirement. This low requirement means that users can get off to a quicker start in their analysis than they can with pure optimisation systems, which require complex data sets at an early stage. With LEAP, the user works by iteration and builds the data set as the analysis progresses (Stockholm Environment Institute, 2017).

Those are only two examples of a very rich range of tools programmed for various types of problematics and technologies. Several reviews have attempted to classify these tools – see, for example, Gargiulo and Ò Gallachòir (2013) or Connolly et al. (2010).

Although those models are regularly updated and improved to include emerging technical solutions or increase the accuracy of their economic assumptions (Loulou and Labriet, 2008; Lund et al., 2004), they are not yet built to reflect the social dimension (e.g., human behaviour and individual and collective opinions) to energy use. Concerning the future of long-term energy modelling, Gargiulo and Gallachóir (2013) review 18 of the most-used long-term energy modelling tools and highlight the main characteristics of each. They state that "the choice of model to study the energy systems is critical and should be fully scoped prior to selecting any existing model", and thus their purpose is to provide users with the necessary information to select the tool most adapted to their needs. Their analysis identifies two areas in particular that remain underdeveloped: land-use and human behaviour. Addressing the former will improve the linkages between agriculture, land-use, energy production and climate. The latter "represents the least understood dimension with macroeconomic models generally assuming rational response to price signals and techno-economic models assuming agnostic behavioural response to technology change" (Gargiulo and Gallachóir, 2013).

Pfenninger et al. (2014) reviewed 10 recent analyses of energy systems models – focusing on the adaptability of the modelling tools analysed, with most of them created before "the advent of modern computing innovations as significant as the internet" – for 21st century challenges such as "capturing the human dimension" or "complexity and optimisation across scales". They conclude by warning of the danger of "proven and established methods [gaining] primacy because of their familiarity", and that "modellers must also make sure to avoid the trap of modelling what is easily quantifiable rather than what are the essential driving variables of the system" (Pfenninger et al., 2014). A similar warning and call for introspection was expressed by Grunwald (2011) when concluding that "as far as we use energy futures for shaping energy policies and are thus giving energy futures a decisive role in this game we should exploit and exhaust all possibilities for increasing reflexivity". He adds that "energy futures can contribute to decision-making in a much more sophisticated and complex way via democratic debate and deliberation" (Grunwald, 2011).

1.3.2.2 Social acceptance

Wüstenhagen et al. (2007) proposed a trilateral clustering of the actors and factors that influence the social acceptance of renewable energy technologies (Wüstenhagen et al., 2007). They distinguished community, market and socio-political acceptance. A point they made was the distinction between overly positive global public acceptance (as measured by opinion polls), which they associated with the socio-political dimensions, and the acceptance levels of local communities who voice more nuanced views (further discussed in section 1.2.5.2). This distinction was important, because in countries where RE projects go through local planning processes with consultation periods, these local opinions can have a determinant impact (Bell et al., 2013). The global public opinion at national level can also influence energy decisions via elections, but past voting results tend to show that a strong inclination towards RE development is not yet one of the most decisive traits for winning elections.

Figure 3 Triangle model of social acceptance of renewable energies. Source: Wüstenhagen et al., 2007

At market level, Wüstenhagen et al. highlighted an element that has strongly shaped the macro/micro situation, especially in terms of this local feeling towards additional wind farms. They observed that the marketing campaigns by companies advertising green power rarely highlighted the physical aspects of building the numerous RE devices suggested. Indeed, neither the competitive field of marketing associated with convincing consumers to opt for green power supply nor the EU large-scale green energy scenarios or national transition policies have clearly displayed to the public what this additional technology will look and feel like. This upcoming impact was never clearly addressed by the many plans, scenarios, advertisements or schemes for greener energy, which treated the spreading of the technology as implicit. Project developers were left to deal with the acceptability of their projects, even in cases of new and visible technologies such as large-scale wind power or pylons. This ad hoc approach excluded the community level from fully grasping, for some time, the extent of the energy transition that had started. Those observations by Wüstenhagen et al. resonated with the numerous studies focused on the isolation of the community level from decisions made by the market and socio-political levels. Sovacool and Lakshmi Ratan (2012) developed this initial framework by associating three sets of factors with each of the initial three dimensions. Miller et al. (2015) argued for the "re-conceptualization of the energy policy imagination", for policymakers to experiment with different types of tools potentially better adapted to consider the multi-faceted nature of energy systems and energy consumption by customers (Miller et al., 2015).

Recently, Fournis and Fortin (2017) detailed their version of an analytical framework that looks into the "collective choices that determine the articulation between technology and society within a specific territory" (Fournis and Fortin, 2017). They develop the concept of social acceptability inspired by Szarka (2007), which adds political and decision processes as key factors shaping the degree of acceptance within each dimension. Published in 2017, the framework includes aspects of the more recent development of the transition. For example, the macro level's key rationality is globalisation – which is now impacting the scale of wind-farm manufacturing currently ruled by companies building internationally – or the scale of the EU and UN decision-making process for emission/RE targets. The competition for large-sized wind projects, likely to be intensified by the adaptation of a tendering process for onshore wind (European Commission, 2014), is fuelling the race among manufacturers to propose more efficient, and hence larger, turbines. While this might be the desired technological and environmental path, it adds to the existing problematics of introducing increasingly tall rotating structures into rural inhabited landscapes. These problematics and the reactions they provoke among local communities characterise the micro or social dimension of the framework.

Almost 10 years separate the frameworks outlined by Wüstenhagen et al. (2007) and Fournis and Fortin (2017), yet they present strong similarities in the way they portray social acceptance/acceptability and the elements associated with each of the three levels. One reason is that many of the elements discussed in the first framework are inherently associated with the institutional and geographical scales described in the second framework. The market dimension is traditionally linked to the macro or global scale for the influential role that multinational businesses play in shaping technological changes; the socio-political dimension is associated with the intermediate meso national or regional scales where authorities shape decision-making mechanisms; and the community dimension is linked to the micro scale to describe the local environment and the individuals who inhabit it.

Finally, as previously mentioned as a motivation for this thesis, Devine-Wright et al. (2017) called for a re-thinking of the general framework of social acceptance towards a greater focus upon "how each dimension inter-relates across different geographical scales (from macro to micro; international, national and local)". The thesis and, more particularly, the article presented in Chapter 3 build from the theories and analytical framework presented by the researchers introduced in this section.

1.3.2.3 STS Approach

The science, technology and society (STS) field of study offers several theories that are useful for navigating the many actors and dynamics that shape the energy transition process. However, this richness can also become a difficulty when a neophyte attempts to figure out which theory would be most adapted to the issue at hand. I will present below those theories that have helped me map actors and dynamics and maintain an open view of each of those actors' sets of actions and objectives. However, this is not an exhaustive list of theories within the field of STS.

In the article presented in Chapter 5, we explore the differences and crossovers between the views of social acceptance expressed by several actors of the translational process as they describe how this impacts their work. I use the framework of social arenas and worlds presented by Clarke and Star (2008) to navigate the landscape created by the "social worlds" that are shaped by the different actors, to examine how those social worlds are created, and, more importantly in the context of this study, to understand how belonging to one world influences actors' behaviour towards other worlds. Indeed, Clarke and Star explain how this framework is useful to study "meaning-making amongst groups of actors […] working with shared objects, which in science often include highly specialized tools and technologies" (Clarke and Fujimura, 1992; Clarke and Star, 2008; Star and Ruhleder, 1996). They describe social worlds as a "universe of discourses", which evolve with time and segment into multiple worlds as discourses and practices evolving within each world. Worlds that revolve around a similar issue, and thus might share similar objectives and issues, then form an *arena* characterised by the shared concern.

Close to the social worlds framework, Chapter 5 also draws from social network research and, in particular, Ronald Burt's concept of *structural holes* and what is used as an answer to this concept –

the role of information or *knowledge brokers*. Burt (1992) first developed his concept in an attempt to explain the differences in social capital among individuals depending on the ties these individuals held with different groups. He developed the concept and defined a structural hole as the "separation between two non-redundant contacts" who hold non-overlapping information (Burt, 2009). This characteristic of actors holding different information leads to the implementation of boundary or information-brokering roles – i.e., key individuals who see the benefits of transferring information between the sides of the structural hole. The systematic review by Long et al. (2013) was particularly useful in developing my understanding of the dynamics that have been observed to structure boundary brokering (Long et al., 2013).

Also on the topic of interactions occurring between actors and groups of actors, actor–network theory (ANT) was not directly used within the articles but helped me further my reflection on what constitutes an actor, and how we are all constantly reacting to our environment and readjusting our understanding and actions based on all that we face; whether it is a person, an object we have to interact with, a disease we have to fight, etc. (Callon, 1984; Jolivet and Heiskanen, 2010; Nimmo, 2011). All that surrounds us, physically or psychologically, affects us and leads us to adapt to it. Due to its far reach, actor–network theory is not 'easy' to handle comprehensively, and getting a sense that an ANT study is complete might mean that it is not. Such an evolving reach implies that applying this theory to structures as broad and complex as our current energy systems is hardly possible for the human mind, at least not for mine. Yet, ANT thinking was a very useful exercise for me to reflect on the actors within energy systems. It reinforced the perceived interests of selecting a broad scope for the thesis and attempting to approach this idea of comprehensive analytical thinking.

Prominent technical researchers have also been calling for policy introspection. In "Soft Energy Paths: towards a durable peace" (1977), the physicist A. B. Lovins discussed the evolving status and implications of policy tools were the US to select a soft energy path as opposed to a hard energy path – namely, decentralised versus centralised production (Lovins, 1977). In these early days of renewable development, Lovins already pointed out how policy instruments used to encourage technological measures are "politically charged" and "likely to irritate us if ill-conceived". With "us", Lovins identifies the local populations who witness technology development and are impacted by national policies for which they have no say. While renewables were still in their infancy in 1977, this lagging discrepancy is also reflected by the policy analyst V. Smil (2010) when he wrote that "inexplicably, much less attention has been given to a key component of this grand transition, to the spatial dimension" (Smil, 2010).

1.3.3 Additional inspiration

The PhD's preliminary focus was the future of onshore wind power. However, initial framing iterations of the thesis highlighted the complexity that defines energy systems and the co-dependency of components and actors. Therefore, by studying one technology only, we ran the risk of missing dynamics between this technology and other actors. Furthermore, a technology might be judged inadequate or obsolete if it fails to secure global social acceptance, and if lessons from those previous U-turns are not learnt, similar conclusions might also be reached for subsequent technologies. Therefore, as discussed in section 1.2 addressing the context, and combining the overarching themes of scales, social aspects and inter-disciplinarity, improving the understanding of social acceptance dynamics within energy systems is ultimately of great interest.

This approach finds some inspiration in the work of philosopher Edgar Morin on complexity and the "complex thought". In his 2006 essay "Restricted complexity, General complexity", Morin discusses how science has evolved towards a strict clustering of topics and how this clustering has become the norm: "*Since a paradigm of simplification controls classical science, by imposing a principle of reduction and a principle of disjunction to any knowledge, there should be a paradigm of complexity that would impose a principle of distinction and a principle of conjunction. In opposition to reduction, complexity requires that one tries to comprehend the relations between the whole and the parts*" (Morin, 2006). Because it is the outcome of many topics usually affiliated to separated arms of science, social acceptance of RE technologies within energy systems is particularly adapted to this idea of moving away from more classical clustered science fields. Morin defines a system as such: "*It is a relation between parts that can be very different from one another and that constitute a whole at the same time organized, organizing, and organizer*" (Morin, 2006). It is indeed this characteristic of being simultaneously organised, organising and organiser that calls for a more comprehensive approach.

Furthermore, in September 2015 I had the opportunity to participate in the Oxford Scenario Programmes, a week-long course on scenario planning. The course introduced the approach of renowned scenario planner Pierre Wack, "the gentle art of re-perceiving", which continues to shape scenario planning methods (Wack, 1985). Among other inspirations, Wack adapted futurologist Joël de Rosnay's (1975) vision of a "macroscope", a symbolic tool that allows a comprehensive exploration of complex systems. Thus, he argued that problem solving would remain ad hoc and solely reactive unless we improved our understanding of the bigger system within which the problems occur (Burt, 2010). Their respective bodies of work have also been a source of inspiration in keeping the larger context in mind throughout the thesis.

The disadvantage of such an approach, compared to the more traditional and segmented science described by Morin, is a lack of details on in-depth policy mechanisms, usually yielded from studies on a specific country or defined by a narrower framing of the policies analysed.

1.4 Study design

1.4.1 Framing and structure of the thesis

In section 1.2.4 I discussed that a conceptual translational process, encompassing the system from international to local scale common across EU countries, is used to frame the thesis (see Figure 4). The objective through this particular framing is to maintain a multi-scalar inclusion throughout the thesis, follow the overarching themes of scales and inter-disciplinarity, and, as such, approach the notion of "complex thinking" as described by Morin (2006) and discussed in section 1.3.3.

This article-based thesis is built around four articles presented in Chapters 2–5. Since the articles are destined for peer-reviewed publication, they have to function as stand-alone pieces, and each one presents different contextual framings, research questions (presented in section 1.3.1) and key theories (discussed in section 1.3.2) that guide their discussions. However, the research questions were designed[4] so that each article would bring elements to contribute to the thesis and the main research question presented in section 1.3.1.

[4] With the exclusion of the article presented in Chapter 4, for which I am co-author. The article nevertheless fits the overall objective of the thesis.

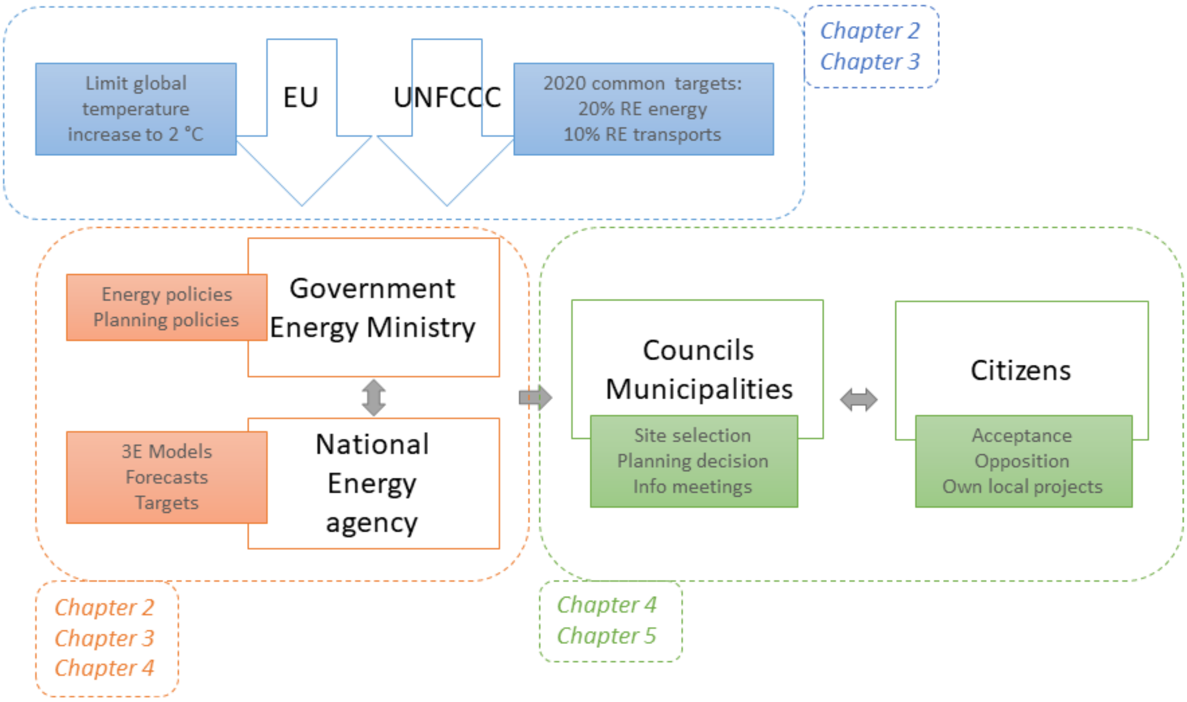

Figure 4 Framing of the thesis as per the translational process presented in Figure 2

The broad multi-scalar topic required a broad trans-disciplinary mixed-research approach. As discussed, the intention with this thesis is to study specific issues while also reflecting on the wider context of energy systems. Therefore, in addition to the initial scalar focus displayed in Figure 4, the discussions endeavour to bring the problematics presented in the articles' core sections to a different scalar perspective. The analytical part of the thesis starts with a global focus in Chapter 2 and narrows the focus with each article while maintaining the broader context. Table 1 below presents the scalar focus of each article, with the arrows showing the direction given to the discussion. The remainder of this section summarises each article, its context and research objectives.

Chapter	2	3	4	5
Overall methodology	Quantitative	Mixed-research	Quantitative	Qualitative
Status of article	Submitted to *Renewable and Sustainable Energy Reviews*	Submitted to *Energy Policy*	Published in *Sustainability*	Submitted to *Energy Research and Social Science*
Scales				
Global				
EU				
National				
Regional/Local				

Table 1 Scalar focus and direction of the articles presented in Chapters 2 to 5

1.4.2 Summary of the four articles presented in Chapters 2 to 5

Chapter 2

The article "The Role of Energy Models in the Sustainable Energy Transition and Social Acceptance of Wind Power" in Chapter 2 presents a systematic review to provide an overview of the body of research examining energy modelling between COP15 and COP21. The purpose of the study is to get some insight into the extent to which social aspects are currently considered in energy modelling studies, and as such present an element of discussion on the relevance of our current methodologies for planning energy futures. Knowing these recent modelling trends that underlie the latest UNFCCC decisions and proposals of INDCs is a crucial step in understanding how the process of translation from GHG reduction instruction to workable plans is being articulated.

The discussion brings the findings on modelling trends into the context of social and community acceptance, arguing that the recent decisions by Denmark and the UK to curb onshore wind power capacities due to limited community acceptance highlights the necessity to address community acceptance in a similar manner as other potential constraints on energy plans.

Chapter 3

The article "How is social acceptance reflected in national renewable energy plans? Evidence from three wind-rich countries" presented in Chapter 3 shifts the focus of the thesis on three EU wind-rich countries – Denmark, Ireland and the UK – to explore how their NREAP policies proposed in 2010 in response to the 2009 EU Renewable Energy Directive articulate social acceptance.

Considering the overall study of the translational process, the study focuses on dynamics across scales. These three countries are selected because wind energy is the cheapest and, so far, most developed new form of RE technology, and consequently they have been adapting their energy systems and policies to that technology. Therefore, studying their policies gives information on how these governments have articulated social acceptance of RE within their sets of policies. We build from the existing literature discussed in section 1.3.2.2 and apply a cross-scalar analytical framework to the three NREAP policy sets.

Similarly to the first article in Chapter 2, we discuss the significance of national policy decisions in the context of local and community acceptance by 'unpacking' the NREAP policies to reveal the levels of focus on market, socio-political and community aspects in each of the three countries.

Chapter 4

The article "Statistical Evidence on the Role of Energy Cooperatives for the Energy Transition in European Countries" presented in Chapter 4 uses empirical quantitative material on energy cooperatives to produce evidence of the role played by cooperatives in Europe in enabling actors of energy transition. We explore how the numbers of energy cooperatives have been evolving in Denmark, Germany, Austria and the UK, and discuss what this evolution means for the role that energy cooperatives have played in energy transition. The main trend observed is that of a decrease in the numbers of cooperatives, which coincides with the removal of supporting schemes and a growing and fierce competition among corporate actors who enter the promising field that cooperatives have opened.

We discuss the role of cooperatives in building social and community acceptance of energy transition and the current shortage of systematic reporting to keep track of cooperatives' role and contribution.

Chapter 5

The article "Differences and cross-overs among actors within the Danish energy planning process" presented in Chapter 5 starts from the finding in Chapter 3 that community acceptance is not comprehensively addressed in policies, and it explores the case of the Danish wind sector through interviews with relevant actors of the energy system. By exploring how the differing actors frame the issue of social acceptance of RETs and wind projects, we identify how the framings differ and overlap. We build on the STS theories described in section 1.3.2.3 to discuss in which ways the differing perspectives of the various actor groups could be reconciled, or even enhanced, by addressing structural holes impeding study of community acceptance in energy transition, and develop knowledge brokers to address them.

Chapter 2

The role of Energy Models in the Sustainable Energy Transition and Social Acceptance of Wind Power

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Abstract

With a focus on the choice of modelling tools, coverage scales and consideration of community aspects, this systematic review of energy modelling and scenario articles published between the Conference of the Parties COP15 and the COP21 highlights the growing trend for national scale and optimisation studies. Meanwhile, decentralised renewable technologies such as wind power have become essential to the global energy transition, yet have also given rise to a new set of challenges, particularly related to acceptance by local communities. Discussing our results on these recent modelling trends in the context of social and community acceptance and our reliance on energy models, for example for Intended Nationally Determined Contributions (INDC) and National Renewable Energy Action Plan (NREAP) calculations, we conclude that there is a pressing need to develop innovative ways to address the dynamics that cannot be easily quantified, and reiterate the call for further collaborative research between energy modellers and social science experts.

2.1 INTRODUCTION

After the global climate mitigation negotiations at United Nations Framework Conference on Climate Change (UNFCCC) Conference of the Parties (COP15) in Copenhagen, Denmark in 2009, an emerging global consensus coalesced on a response to climate change (UNFCCC, 2015), based on "common but differentiated responsibilities and respective capabilities, in the light of different national circumstances" (UNFCCC. Conference of the Parties (COP), 2015). This culminated in the agreement reached in the COP21 in Paris, France, in 2015 - the so-called "Paris Accord." The foundation of the Paris Accord are INDCs (Intended Nationally Determined Contributions) which outline each country's pledge to mitigate climate change by setting an emissions target (or emissions intensity of GDP target) and an implied pathway. Among other things, the INDCs require countries to make long-term goals for their national energy systems.

Nations face the task of developing a mix of energy sources capable of meeting the demand for energy services in a secure, sustainable and affordable way. Policy decisions are influenced by dynamic and multifarious criteria that are in constant flux and face complex internal and external trade-offs (Rogge et al., 2017). Many considerations influence how the optimum energy mix is framed, including existing infrastructure, the nature of energy demand, competing public and private economic interests (and variable distribution of power to secure those interests), public attitudes, energy security, the costs and availability of resources, the potential for imports, investors' interests in new technologies, the capacity for indigenous technological innovation, national and international regulatory constraints and the capabilities of a wide range of key actors, etc (Kern and Rogge, 2016). Indeed, over the past five decades we have seen how triggering events (such as the oil crises of 1973 and 1979), evolving understanding on the risks faced by energy systems (such as reliance on singular energy sources) and the threat of climate change have all lead to a profound shift in the normative notion of an 'optimal energy mix' (Fouquet, 2010).

The ability to forecast different energy futures has evolved over the last five decades. The first instalments in the 1970s, resulting from linear programming developed during the Second World War, were only concerned with production, demand and the cost-optimisation of energy sectors. In the 1980s, due to increasing public concern about the environmental impacts of energy production, modellers began to include aspects such as greenhouse gas emissions into the models (Ribeiro et al., 2011). Since then, numerous models have been developed with an increasingly stronger focus on the ability to comprehensively inform climate policies and maintain financial relevance. Labelled 'energy scenarios', 'roadmaps', or 'strategy plans', these long-term transition plans project energy use over several decades: often until 2050, 2100, or even beyond.

Although the models upon which these plans are based are continually being improved to include emerging technical solutions or to increase the accuracy of their economic assumptions (Loulou and Labriet, 2008; Lund et al., 2004), they struggle to effectively reflect the social dimension (e.g. human behaviour, individual, and collective opinions) of energy use, development and demand. Indeed, in their review of 18 of the most-used long-term energy models Gargiulo and Gallachóir (2013) found that human behaviour "represents the least understood dimension with macroeconomic models generally assuming rational response to price signals and techno-economic models assuming agnostic behavioural response to technology change" (Gargiulo and Gallachóir, 2013). Similarly, Pfenninger et al. (2014) reviewed ten recent analyses of energy systems models and found that they were insufficient at "capturing the human dimension" or "complexity and optimisation across scales". This echoes the conclusion from Grunwald (2011) that "as far as we use energy futures for shaping energy policies and are thus giving energy futures a decisive role in this game we should exploit and exhaust all possibilities for increasing reflexivity".

In a review of energy research, Sovacool (2014) highlights both the under-appreciation and substantial value of social science engagement with energy issues. Drawing on a quantitative and qualitative review of 4444 articles published in three leading energy journals (*Energy Policy, Electricity Journal and The Energy Journal*) between 1999 and 2013, Sovacool (2014) suggests that only 19.6% of authors came from the broad range of social science and of the 90,049 references cited in these papers, only 5% came from social science or arts and humanities journals. Similar trends were found in relation to content, methods and funding sources. In concluding his review, Sovacool (2014) noted that core social science disciplines such as politics, psychology and sociology - along with their insights on human behaviour and social organisation - have been seen as peripheral and secondary to the 'harder' or 'objective' fields of economics, mathematics, engineering or physics. A consequence of this is that our understanding of the complexity of energy is incomplete, and without a more effective inter-disciplinary approach to energy research it is not possible to fully grasp that "energy is meaningful not by being consumed itself, but because it makes certain services possible and intersects with and compliments behavioural routines and habits" (Sovacool, 2014, p. 25) . Furthermore, in failing to embrace the wider insights into uncertainties arising from the cultural, subjective and value-based dimensions of energy, it is likely that attempts to forecast future trends in energy use will inevitably struggle in their explanatory power (Geels and Schot, 2007).

Viewing the energy transition in a wider socio-technical context makes visible important issues of technology deployment that are otherwise left unseen (Miller et al., 2013). This is increasingly recognised in relation to the deployment of different renewable energy technologies, where social issues, particularly related to acceptance, have in some cases become the limiting factors to expansion rather than technological or economic factors (Batel and Devine-Wright, 2015; Borch et al., 2017; Haggett, 2010; SLR Consulting et al., 2014; Wolsink, 2007a). As part of this research focused on the new dynamics entailed in the energy transition, Wüstenhagen et al. (2007) have defined social acceptance as the combination of three dimensions: community, market, and socio-political.

Generally, models are designed to optimise the system by simulating a market subject to user generated socio-political scenario constraints, for example, optimisation analysis that seek to establish a least-cost scenario, or calculations of costs from a set of policies. As such, some researchers have also questioned the constant production of new energy scenario material and have called for further reflection on the process, particularly the use of optimisation modelling and its deterministic role (Grunwald, 2011; Jefferson, 2014).

In terms of the guidance given to countries as part of the energy transition, the Climate Development and Knowledge Network created a report with 10 recommendations for the creation of INDCs for developing countries. They recommend that the INDCs be consistent with national development goals and be SMART: Specific, Measurable, Agreed-upon, Realistic and Time-bound (Bird et al., 2017). They provide examples of emissions pledges against baseline scenarios, implying that energy models would be a necessary tool to calculate these. They also recommend the need for broad national support but point out that the tight timeline of the Paris Accord makes this process quite challenging, and note that consultation has generally been with those already engaged in national development planning (Bird et al., 2017); also implying the use of more top-down assessment tools. The preliminary INDC guideline proposed by the EU in March 2015 indeed indicates textually the Commission's focus on "quantifiable information" to describe the components of the future INDC (European Commission, 2015a).

Therefore, given the INDC framework, national energy models are the main tool nations use to determine their emissions contributions (UNFCCC. Conference of the Parties (COP), 2015; World Resources Institute, 2018, 2015). Moreover, given the tight deadline, it is likely there is insufficient time to conduct in-depth stakeholder and community-based social acceptance studies (Stirling, 2008). Thus, the aspect of social acceptance, if it is to be considered at all in national energy plans, would need to be included in the energy modelling.

In light of these recent evolutions, and the partial backtracking on onshore wind power done by Denmark and the UK due to issues with community acceptance, the purpose of our study is to get some insight into the extent that social aspects are currently considered in energy modelling studies, and as such present an element of discussion on the relevance of our current methodologies for planning energy futures. To get this insight, we conduct a systematic review of articles on energy system modelling studies published in three major journal databases between 2009 and 2014. The year 2009 is chosen as the starting point as this was the year that the COP15 in Copenhagen led to no global agreement, and the year that EU member states signed the Renewable Energy Directive, which aimed to ensure steady growth in renewable energy production (Council of the European Union, 2009b). The year 2014 was chosen as the last relevant year for literature to influence the 2015 COP21 meeting in Paris.

There were three steps in the data gathering and analysis, which included a systematic review and a content analysis contextualising the results in terms of study types, modelling tools, scales and consideration of social aspects. The final step consists in a discussion of the results in the broader context of the energy transition and focusing on the following questions: what are the most commonly used energy modelling tools and how do these frame the model outputs; what are the geographical scales of these models and how does this influence the type of data included; and how are the resulting expressions of energy futures related to the dynamics of social acceptance, including the community dimension?

2.2 Systematic review methodology

The review applies the approach recommended by Roberts and Petticrew (2006), and the resulting selection protocol is summarised in Table 2 (Petticrew and Roberts, 2006). The articles were added to Mendeley, a literature management tool. The selected criteria (Table 2) were fed into an extraction form, and criteria that could not be extracted directly from the documents were obtained manually to maintain the accuracy of the results. To further refine the sample, second keyword strings were applied.

Characteristics	Description
Period of data collection	1 September 2014 to 30 June 2015
Period of data publication	January 2009 to December 2014
Tools	Scopus, ScienceDirect and Web of Science
Sources of documents	Peer-reviewed journals
Language	English
Inclusion criteria	Full-length published articles of studies: • considering the entire energy system of a defined national or subnational area • focusing on one particular energy source, though seen as part of the entire energy sector in the area of interest • including onshore wind power as part of the global energy system
First keyword search strings	scenario* AND renewable* AND energy AND polic*
Sample size	562
Second keyword search strings	model* AND wind
Papers rejected	275
Sample size after second keyword search	287
Geographical representation	90 countries Energy modelling studies that grouped several countries together (e.g. EU) were not included, as they are considered less likely to include aspects of community acceptance
Energy modelling tools highlighted	85

Table 2 Review selection criteria

Following the second keyword-based selection, a quality appraisal and relevancy check was conducted:

- Does the article present some form of scenarios for the energy system of a clearly delimited area? Yes/No
- Is the article based on some form of modelling work? Y/N: Only articles that mention or discuss some form of modelling linked to energy planning were included. Selected articles do not have to present their own modelling study, but might discuss modelling results from another study or report, with or without naming the modelling tools.
- Is wind power part of one or several of the scenarios described by the article? Y/N: The required inclusion of wind power is motivated by the status that this technology has acquired within the energy transition, both positively as an increasingly inexpensive means to produce renewable electricity, but also negatively as new sites are regularly contested due to their impact on the landscape.

Finally, concerning the avoidance of errors and bias, an introspective process adapted from the common methods used to assess the objectivity of systematic reviews (Jadad et al., 1996) was applied, and previous entries were regularly and randomly re-checked.

2.3 CONTENT ANALYSIS

The articles were further analysed following content analysis methods (Neuendorf, 2016; Neuman, 2003). Aside from collecting the basic data of each article (name(s) of the author(s), journal, and time of publication), we gathered the following information to illustrate the characteristics of this body of research: study types, modelling tools, scale focus, and considerations for social acceptance.

2.3.1 Study types

The articles were then categorized: a typology was developed from the 287 abstracts, with each article being assigned to one of the six categories based on its preliminary focus, methodology, objectives, and potential modelling tool(s). In those cases where the category allocation was not evident from the abstract, the entire document was analysed.

The six categories are described and exemplified in Table 3, while the distribution per year of each of the identified study types is presented in Figure 5.

Energy sector	**The "Energy Sector" type represents cross-disciplinary studies with a high level of inclusiveness of various sectors, technologies and energy resources, often from a system-wide perspective. This category includes studies that attempt to cover all the main aspects of an energy sector. Some go further by adding transport sector data. These studies are often realised using optimisation models (e.g., TIMES or the version of TIMES already adapted to the country analysed), simulation models (e.g., EnergyPlan), or multi-approach tools (e.g., LEAP). For example, Chiodi et al.'s (2013) study of the Irish energy system (Chiodi et al., 2013), Usher and Strachan's (2010) study of decarbonisation pathways for the UK (Usher and Strachan, 2010), Hong et al. (2013) exploration of an active renewable energy scenario for Jiangsu province by 2050 (Hong et al., 2013).**
Prospects for Renewable Energy	This type includes studies that focus on the feasibility of developing further renewable energy sources, usually within a given territory. Since no study published between 2009 and 2014 focuses solely on the development of fossil fuels or nuclear power, this category focuses on the prospects for renewable energy, with other sources (such as fossil fuels or nuclear) present as part of a wider energy mix. These feasibility analyses are often based on the land area available for new technologies, the existing infrastructure required for their development, and/or current political priorities. For example, Nagamani et al. (2015) review of RE scenarios for India (Nagamani et al., 2015) or Cho and Kim (2015) – a feasibility study of a RE-based system in Korea (Cho and Kim, 2015). In very rare cases (such as Arent et al. (2009), on the potential for RE for the State of Hawaii (2009) (Arent et al., 2009)), the population's perceived openness to such developments is mentioned.

Policies	Studies in this category analyse the impacts and implications of one or several sets of energy policies. Recent policies in European countries tend to encourage the development of renewable energy, including the 2009 Danish Promotion of Renewable Energy Act, the 2011 British Renewable Heat Incentive (updated in 2015), the 2014 Ireland Offshore Renewable Energy Development Plan, and the 2010 European and Binding National Renewable Energy Action Plans. These examples represent policy packages that often encourage reduced taxation for renewable technologies or the adaptation of existing feed-in tariffs to the latest evolution of the energy market. Such incentives are closely linked to changes in government priorities and are therefore difficult to predict, so that policy studies tend to limit themselves to existing policies or assumptions about the near future. This type includes, for example, Mondal et al. (2013) on the policy implications of a long-term optimization of the energy future for United Arab Emirates (Mondal et al., 2014), and the Anandarajah and Strachan (2010) study of the interactions and implications of climate change policies in the UK (Anandarajah and Strachan, 2010).
Renewable Energy Integration	These studies are similar to the Prospect for RE category but focus more precisely on the transmission challenges and technical feasibility of integrating a given amount of renewable power into a grid infrastructure to a much greater degree. Examples include Karapidakis et al. (2010) on the high penetration of RE in Crete (Karapidakis et al., 2010), or Howard et al. (2009) study of the impact of sustainable energy production on land use in the UK until 2050 (Howard et al., 2009).
Economics	This category includes studies that focus on the financial characteristics or consequences of potential energy futures, for example, the cost of a technology associated with a particular energy scenario or the attractiveness of investments in new renewable technologies, including the impact of different incentives or policy initiatives. For this reason, these studies are strongly linked to local and national energy policies and use financial forecasting modelling techniques. Examples include Anandarajah and McDowall (2012) estimation of the costs of climate and renewable policies in Scotland (Anandarajah and McDowall, 2012), and Amaral et al. (2014) economic and environmental assessment of renewable energy micro-systems in a developing country (Amaral et al., 2014).
Footprint	Studies in this category seek to quantify the environmental impact and CO_2 emissions associated with the development of energy plants and devices. Given that the studies reviewed here were published between 2009 and 2015, a key topic is the carbon cost of life cycle assessments for renewable energy devices. Such studies often use existing energy scenarios and add environmental costs and benefits to the analysis. These studies arguably do not fit neatly within the scope of this review, as they do not always conduct the scenario analysis themselves. However, because they focus on completing existing scenario analyses by examining a wider and more comprehensive picture, they have been considered relevant although they are not common. Examples of this type are Alderson et al. (2012) footprinting low carbon UK electricity futures to 2050 (Alderson et al., 2012), and Santoyo-Castelazo and Azapagic (2014) sustainability assessment of energy systems with integrating environmental, economic and social aspects in Mexico (Santoyo-Castelazo and Azapagic, 2014).

Table 3 Types of energy modelling and scenario studies with descriptions

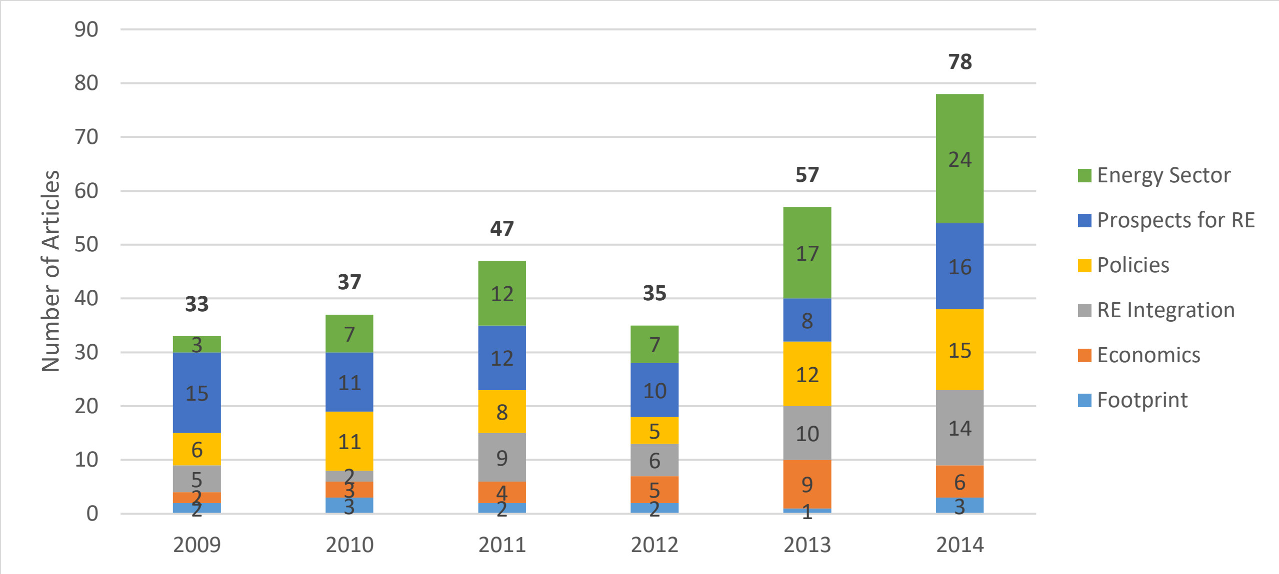

Figure 5 Distribution of numbers of reviewed articles per study type and year of publication

We observe that the number of articles increases almost steadily every year, from 2009 to 2014. This growth is distributed among the identified study types; although the Energy Sector type has the highest global increase in the type none (see Figure 5). Corroborating Sovacool (2014), we find that the body of peer-reviewed work on energy scenario modelling is broad both in terms of the number of articles and the various methodological and disciplinary approaches deployed (Sovacool, 2014). The significance of the increase in the total numbers of articles (from 33 in 2009 to 78 in 2014), and the evolution relative to the six identified study types, are further analysed in the discussion in section 2.4.

2.3.2 Modelling tools

Each article was associated with the modelling tool(s) used in the study. In cases where several tools were used complementarily to each other, these tools were all listed, even if one was more extensively used than the others. In cases where the modelling tool was a sub-version of a broader type, efforts were then made to associate those articles to this broader type to reflect the overall research background and affiliation of each article. In certain articles, no tool could be identified and these articles were then classified as “none”.

Within the sample of 287 articles the content analysis identified 85 distinctly named modelling tools, and 48 that were developed by the author(s) and left unnamed. Additionally, 80 articles discuss quantitative energy modelling results as part of their study, without using and naming a particular tool. Among the 85 studies that identified tools, the three most used were the Markal/TIMES products with 39 uses, LEAP or Long-range Energy Alternatives Planning with 18 uses, and EnergyPlan with 14 (See Table 5 and further details in boxes 1-3 below). The other

77 tools appeared a total of 99 times across all papers. Thus, the three main tools represent 34% of the use of such models within the sample of 207 studies with named modelling tools[5].

Total number of modelling software or methods used and named by authors	**85**
Number of studies with models developed by the researcher or research team	48
Number of studies that discuss modelling results but do not name the tool	80

Table 4 Numbers of energy modelling tools identified

Most used energy models	No. of uses	% among 207 studies that mention using modelling tools	Type
ETSAP-TIAM products	39	19%	Optimisation
LEAP	18	9%	Simulation, added optimisation mode
EnergyPlan	14	6%	Simulation with optimising functions
Total	71	34%	

Table 5 Most frequently used energy models

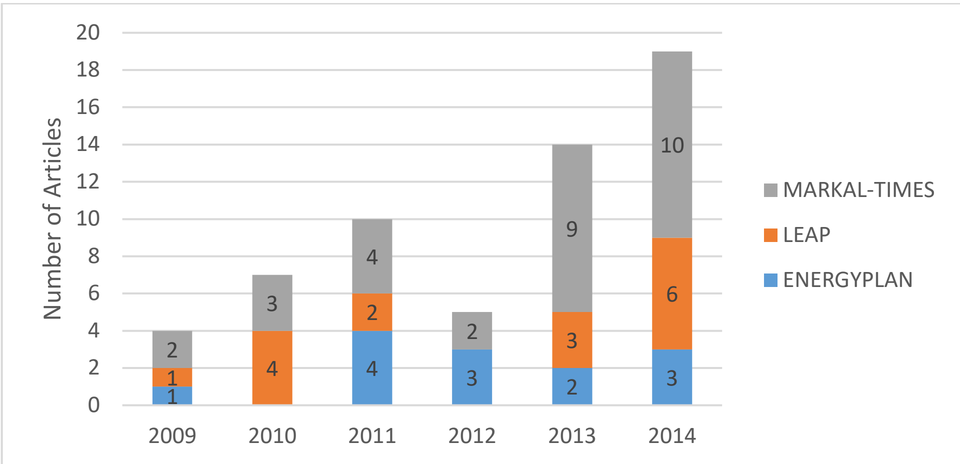

Figure 6 Annual distribution of uses of the three most frequent energy modelling tools

The distribution between 2009 and 2014 in Figure 6 shows the total number of studies per year and the associated use of energy modelling tools. The overall use shows a strong increase between 2009 and 2014, while among the three most common tools, the optimisation Markal/TIMES tools have seen the sharpest rise.

In terms of study types, the overall increase in the number of energy scenario studies is driven in particular by growth in the "Energy Sector" type from 2 identified articles in 2009 to 24 in 2014. This follows the rise in articles using Markal/TIMES tools, which are particularly adapted to optimisation studies of the whole energy sector. This prioritisation of optimising methods is also

[5] Certain articles use several modelling tools as part of their methodology, consequently the total number of articles and number of modelling tool uses do not match.

observed across the whole sample, with 82 studies opting for optimisation as their main methodology between 2009 and 2014, against 65 choosing non-optimisation methodologies[6] such as simulation, or 55% of optimisation methodologies. This overall trend is displayed cumulatively in Figure 7 where the number of studies employing optimisation methods is seen to be increasing faster than studies using other non-optimising methodologies during the same period, and ends with a lead of 26% by 2014. The significance of this increase and occurrences of the different study types are further analysed in the discussion in section 2.4.

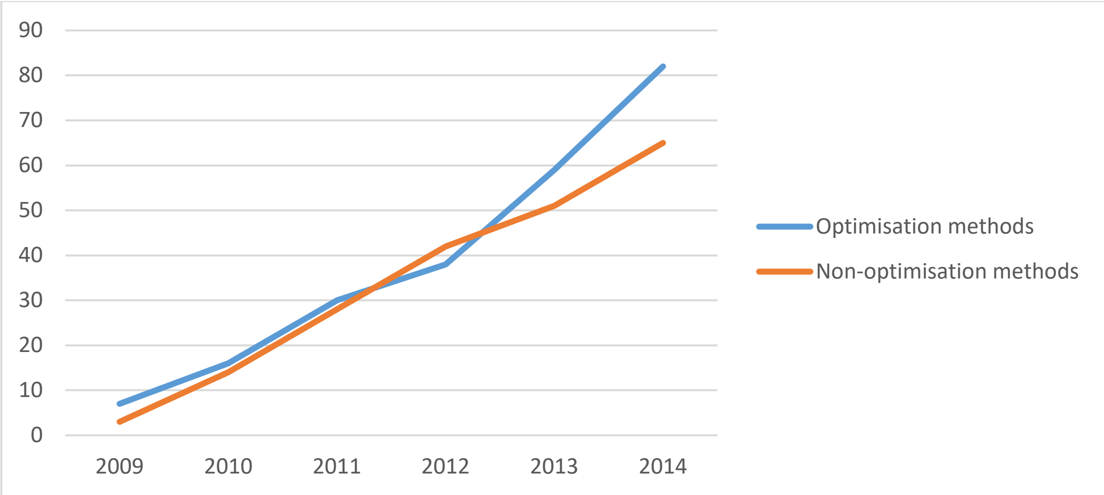

Figure 7 Cumulative amounts of selected energy modelling methodologies

2.3.3 Geographical scale

Articles were also classified according to the country or other coverage-area that they focused on. In cases where the focus was on several countries or areas individually, they were all listed. The resulting list of countries and areas was then further analysed to identify whether the coverage was one or several countries, or a subnational area.

Most studies analyse the energy sector of an entire country, (e.g. China (Cai et al., 2013) or Portugal (Damas et al., 2008)), however, our review identified 47 articles (see Table 6) focusing on a region rather than the entire country (e.g., the Waterloo region in the Netherlands (Cai et al., 2008) or the isle of Crete in Greece (Emmanouilides and Sgouromalli, 2013)). These subnational studies represent overall 16% of those reviewed. The share of studies opting for this coverage has also decreased between 2009 and 2014 (see Table 6 and Figure 8).

[6] The distinction between optimization and non-optimising methodologies follows that of reviews from Connolly et al (2010) (Connolly et al., 2010), Gargiulo and Ò Gallachoìr (2013) (Gargiulo and Gallachóir, 2013), and own assessment based on the description of the tools by the authors of each study.

Publication Year	No. of subnational studies	Total no. of studies	%
2009	7	27	26%
2010	6	31	19%
2011	9	42	21%
2012	6	35	17%
2013	7	57	12%
2014	12	78	15%
Total	47	270	17%

Table 6 Reviewed articles at subnational scale per year of publication

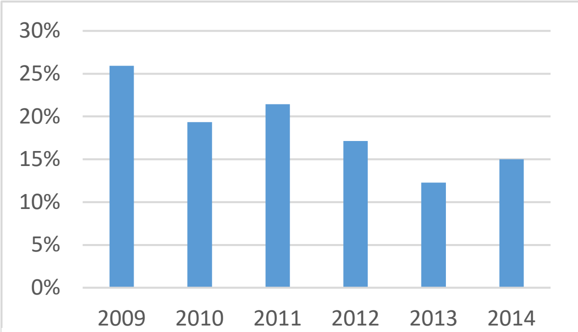

Figure 8 Proportion of energy scenario studies at subnational scale per year of publication

In terms of study types[7], Figure 9 illustrates that the number of studies for each type varies depending on the geographical scale. Studies that focus on an entire nation state —the most frequent kind by five to one — show similar proportions within "Energy Sector", "Prospects for Renewable Energy", and "Policies" categories.

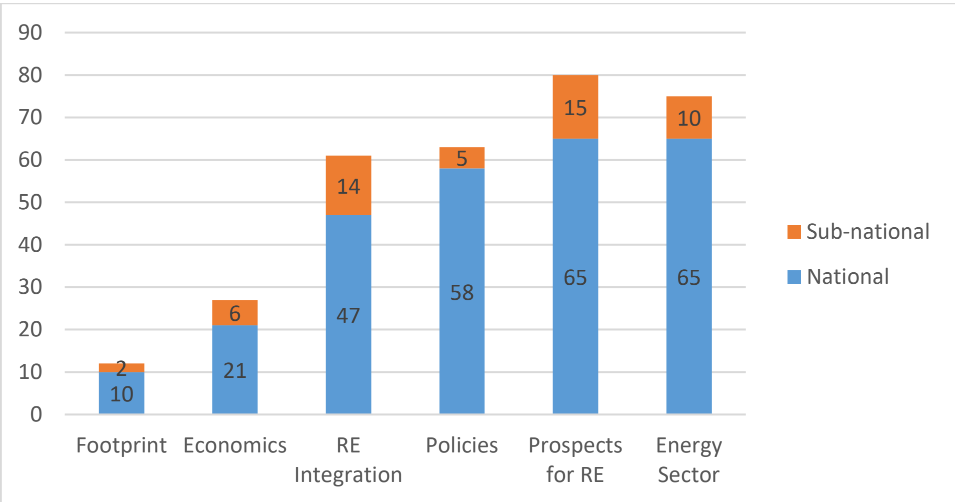

Figure 9 Number of studies per type at national and sub-national coverage

The "Prospects for RE" type represents a high share within both numbers of national and subnational studies, which indicates the ongoing interest in the development of renewable energy at various geographical levels. The results differ for the "Integration of Renewable Energy" category, which focuses on the addition of renewable power in a grid network. Here, the review found almost 50% more of this type among subnational studies than among national studies. The

[7] See description of study types in *Table 3*

results presented in Figure 8 and Figure 9 are further analysed in the discussion in section 2.4 for their significance on the evolution of scales in modelling studies.

2.3.4 Consideration for community aspects

We searched for key terms[8] commonly associated with the themes of community acceptance or opposition, and social inclusion within the processes that form energy transition. The list of keywords was generated from representative studies within the field of wind power acceptance (Batel and Devine-Wright, 2015; Borch et al., 2017; Haggett, 2010; SLR Consulting et al., 2014; Wolsink, 2007a; Wüstenhagen et al., 2007). We noted both the existence of the selected keywords in the sample of articles, and the average occurrence rate in the articles in which they appear. Each occurrence was checked to ensure that the use of the term fell within the contexts of public involvement, acceptance or opposition.

Key Terms	Number of articles	% of articles within sample of 287	Max word count	Average per article
Community	47	16%	16	3.3
Behaviour	32	11%	13	2.3
Citizen	31	10%	11	2.4
Participation	26	9%	13	2.5
Public acceptance	18	6%	15	2.2
Social acceptance	17	6%	16	2.5
Involvement	12	4%	6	2.1
Public opposition	10	3%	2	1.1
Visual impact	7	2%	22	5.6
Local population	2	1%	1	1.0
Public concern(s)	0	0%	-	-
Social concern(s)	0	0%	-	-

Table 7 Maximum and average occurrences of population-related terms

The analysis in Table 7 of how the community dimension is represented through use of selected keywords, suggests this has a low presence in energy modelling studies. "Community" is the most commonly mentioned expression with 16% of the 287 articles and an average of 3.3 times per article, while of the selected expressions and keywords "local population" is the least mentioned, appearing in only 1% of the articles. The terms linked to community engagement, such as "involvement" and "participation", appeared respectively in 26% and 12% of articles with average counts of 2.6 and 2.2 times per article. The terms linked to potential conflicts, "public opposition" and "visual impact", appeared on average 1.1 and 2.8 times in 3% and 2% of articles. Also, directly

[8] Keywords: Community, Behaviour, Citizen, Participation, Public acceptance, Social acceptance, Involvement, Public opposition, Visual impact, Local population, Public concerns, Social concerns

associated with potential conflicts and upcoming obstacles, "public concern(s)" and "social concern(s)", were not found in any study.

2.4 Discussion

The increase displayed in Figure 5 in the number of modelling articles throughout the period between the 2009 COP15 and the 2015 COP21 show the increase in academic interest for the assessment of future energy scenarios to support the development of the INDCs. As seen in Figure 6 with a faster rise in the use of the optimising tool TIMES, and more generally in Figure 7, this increase was slightly higher in studies using optimising tools as compared to non-optimising tools. This implies that the focus has been more frequently directed by least-cost economic pathways in constructing future energy scenarios, and studies from this perspective tend not to consider social or community acceptance aspects within these scenarios.

The Stockholm Environment Institute, creators of energy modelling tool LEAP, give the following disclaimer for new users of optimisation calculations: "One thing to remember with optimisation calculations is that the model tells the user what future configuration of the energy system will yield the lowest overall cost to society. Such pathways may not necessarily represent realistic policy options in a particular country for many different reasons such as the social and environmental acceptability of certain technologies or the need to preserve diversity and energy security" [53]. They point to the critical role of modellers in 'controlling' the extent of the optimisation and discerning what scenarios best adapt to the areas' current evolution in terms of feasibility. Meanwhile, optimisation model researchers would point to the ability of their tools to identify the least-cost path (absent societal and political considerations) as a strength of their models, rather than a weakness, the implication being that politicians and policy-makers can then provide the subjective societal and political context. This "subjectivity" was illustrated for example by the recent decisions by Denmark and the UK to limit support for onshore wind, due to localised but recurrent complaints from opponents in the communities who have been claiming that their quality of life had been negatively impacted by turbines (Haggett, 2010; Munk, 2015; Toke et al., 2008). If we consider that Denmark and the UK were planning a few years ago to take further advantage of their large onshore wind resources (Department of Energy and Climate Change, 2009; Mathiesen et al., 2009; The Danish Ministry of Climate and Energy, 2011), the situation described here bears questions regarding the balance between balance between technical regulatory approach to planning and a more collaborative approach that include social issues that impacts community acceptance. Such examples highlight the gap between economically optimal pathways as computed by models and actual policy decisions, and by not considering social acceptance, we run the risk of invalidating the pathways. In these instances, the optimisation models would need to, a priori, constrain onshore wind in order to determine the next best suite of technologies. Considering social acceptance a posteriori renders the pathway less than optimal.

Of course, by definition, all models create simplified versions of reality in order to generate usable results, and this has allowed them to calculate energy system pathways that include the ever-increasing complexity of developing technologies. This is not to say the models are right or wrong; they calculate a solution given the structure, input data, and constraints set by the modellers. It does underscore, however, the importance of including social acceptance within the modelling (in at least the scenario constructions) as these can be just as important as the technological and economic considerations that underlie the model structure.

From the point of view of optimisation, it is highly dependent on the subjective choice of scale; what is optimal at the national level, for example, may not be optimal at the community level or even the global level. As displayed in Figure 8 and Figure 9, the large majority of the studies in the literature for this period were at the national scale and were categorized as "Energy Sector" studies – this type of study growing in importance at a faster rate than any other category to become dominant type of study in 2013 and 2014 (see Figure 5). This finding shows that the modelling began to increasingly take broader and more inclusive angle.

This development, which follows the push by UNFCCC and for standardised carbon reduction intentions at the national level, has both positive and negative potential consequences. On one hand, it is indeed positive to address the many of the co-dependent issues within energy systems in a comprehensive way. Further standardisation also allows more scrutiny into the results. On the other hand, this evolution towards broader studies may lead to further simplification of dynamics at sub-national scales, dynamics whose heterogeneity has been otherwise researched (Gamboa and Munda, 2007; Johansen and Emborg, 2018; Warren and McFadyen, 2010). As localised lack of acceptance has the capacity to disrupt national plans, we therefore argue there is still a place for subnational studies with a narrower focus, which could better represent social acceptance at the local level.

The value of maintaining a range of areal focus is also discussed within other commentaries on the scale of energy policy research, including Cowell et al. (2017) (Cowell et al., 2017) and Coenen et al. (2012) (Coenen et al., 2012), who note how subnational governments have the potential to have a greater role in developing more decentralised and diversely-owned energy systems. Even countries that have formally devolved governments (e.g. Scotland) beside their national governance appear to have only limited competences at the subnational (Muinzer and Ellis, 2017), for example in the case of the UK (Cowell et al., 2017). In countries without devolved powers, there is little discussion on subnational governance, and national policies are predominant. Thus, outcomes of energy modelling at subnational levels face fundamental obstacles for being transferred into policies, which is, in broad terms, the goal of energy modelling.

The feasibility of both national and sub-national studies lies with data availability. At the national scale, data parameters are more standardized, as most countries have national statistics bureaus, and there are many multinational organizations that collect national level statistics (e.g. the IEA, IPCC, etc.). However, due to the increasing demand for comprehensive integrated analyses, national level models tend to increase in complexity as they are developed, resulting in an increasingly large number of default assumptions for parameter values. The level of accuracy of modelling results depends on the comprehensiveness of the exogenous default values for model parameters (e.g. cost curves, efficiencies, elasticities, etc.) (Chiodi et al., 2013). Continually updating and recalibrating parameter assumptions becomes increasingly less feasible as models increase in complexity. Thus, and despite national scale standardization, modellers frequently state how data collection for exogenous input data values (e.g. fuel prices, population, household income, etc.) remains a challenging aspect of energy modelling ("Personal communication," 2016).

At the subnational scale, the data are not standardised and the availability is variable (Andres et al., 2012; Gurney et al., 2007). For models operating on the subnational scales, the model structure must conform to data availability. When attempting to apply a given subnational model to a different area, data may not be available for the set of parameters in the model, thus requiring structural changes. Alternatively, subnational data might become available through disaggregation of national data (Gregg et al., 2009), which is an extra task for the modeller and lengthens the time allocated to the study. A further difficulty is that subnational regions and their corresponding datasets might be defined differently depending on geographical or political decisions. Thus, available subnational data do not easily correlate with the intended framework of the study, standardised datasets, or the operating structure of the model, associating subnational studies with lengthened data collection and calibration for potentially incomplete results when compared to national datasets with standardised datasets (*Interview with SEAI 06-11-15*, 2015).

Considering the complexity and vast amount of assorted data required, the observed prevalence of national studies is not surprising, as data availability thus shapes model structures (Pfenninger et al., 2014). This homogenisation of scales and the decrease in the number of subnational studies is likely to result in a loss in the variety of geographical coverage for collected data, and could ultimately affect the level of resources that are dedicated in the public and private sectors to collecting and managing such datasets. As a result, conducting subnational energy studies may become increasingly challenging in terms of obtaining and harmonising exogenous non-standardised datasets.

These recent trends in modelling tools and scales are further nuanced below with the keyword analysis on community acceptance presented in Table 7. The analysis was conducted across the whole sample to provide a basic insight on the way the fields of modelling and community acceptance of technologies crossover within the 287 modelling studies. The relatively low occurrence of terms related to community acceptance was not entirely unexpected because, as mentioned earlier, large-scale modelling tools were not currently designed to address such dynamics. Data on community acceptance typically carry complex qualitative nuances, such as individual views of opposition or support, or notions of place attachment, which cannot easily be transferred to a large modelling frameworks (Devine-Wright, 2013b; Devine-Wright and Howes, 2010).

Nevertheless, there are growing numbers of model-based approaches that explicitly integrate behaviour into their analysis, such as the CIMS model family, which has included stated preference information from behavioural surveys into the algorithms used for actor decision making since the 2000s (Rivers and Jaccard, 2005), and the Socio-Markal (Nguene et al., 2011), which is being developed for a 'social' version of Markal. Further efforts are on-going in the global IAM community to improve behavioural elements (McCollum et al., 2017). While the occurrence of terms related to social dynamics are low, those efforts demonstrate the focus within the modelling community on addressing some of the known shortcomings of existing modelling tools (Moallemi and Malekpour, 2018). However, "behavioural data" is a general term for a broad range of behaviours and the topic of community acceptance cannot, as of yet, be implemented within models at the scale where national decisions are made. Our findings here suggest that the consideration for levels of community acceptance is still low and therefore does not yet match the growing influence of community acceptance of technologies.

2.5 Conclusion

This study endeavoured to examine the modelling of the current energy transition towards greater renewables and shares of decentralised technologies within the context of social aspects and social acceptance, and as such presents an element to support further interrogation on how energy planning relates to populations who directly experience the technologies prioritised by modellers and decision-makers. Across the sample of 287 energy modelling studies we find a predominance and increasing trend of studies employing national scale and/or optimisation methods in the modelling studies between 2009 and 2014, and argue that this trend stands in potential conflict with the recent findings concerning the growing threats from failing community acceptance. Because the body of research characterised by our sample underlies the formation of the INDCs, it is likely that the de-carbonisation pathways contained in the INDCs do not adequately include social acceptance.

This increases the risk that national governments will face often-unexpected local barriers not yet identified by INDCs when implementing their energy plans. When facing opposition and cancelled projects, this also increases the risk that the ultimate pathways for the energy transition may be less economically optimal and therefore more costly to society and take longer than anticipated. Indeed, several national energy plans have ended up conflicting with localised visions of optimality or quality of life. This has led to some alterations of the national plans, despite the vast availability of renewable energy (e.g. wind) resources. Therefore, we see a need to remain inquisitive of the degree of comprehensiveness that defines the energy planning process, and query whether we are using all available skills and data as strategically as we could. We join the existing call for further research on innovative ways to complement the optimisation modelling process with a direct collaboration with experts into all aspects of human behaviours. However, we add that there is also a need to develop ways to address behaviours that cannot be easily quantified, such as community acceptance, so that the limitations in their understanding do not lead more countries to discard valuable technologies without further efforts to address a potential opposition. One issue therefore here might be that in considering the 'cost' of different technologies, there is some provision made for the differential investment in 'community relations' to be made by different technologies - e.g. community benefit funds, shared ownership etc, which in some circumstances could alter the viability of one modes of generation over another.

Our study has explored a key component of energy planning that has heretofore been often-neglected. We argue that there exists an opportunity to bolster the models and the energy planning process to be more effective in the future. This becomes increasingly salient, as our reliance on modelling tools is not just about planning energy systems but more than ever about addressing the global challenge of climate change. Indeed, the IPCC has analysed the various INDCs and have determined that they are not ambitious enough to meet the goals of the Paris Accord (IPCC, 2017). The report shows that more efforts over the next decade are needed to prevent warming over 1.5 degrees C over pre-industrial times, and to reach such a target will require a radical transformation of our energy systems. Such a transformation implies greater impacts at the local level than those so far experienced. To increase the likelihood of success, new decarbonisation pathways should incorporate aspects of social acceptance into the models that offer decision support to the energy planning process and overall transition.

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Chapter 3

How is Social Acceptance Reflected in National Renewable Energy Plans? Evidence from Three Wind-Rich Countries

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Abstract

This article explores the 2010 NREAP policies of three European countries with high wind resources: Denmark, Ireland and UK. These high resources, combined with a need for diversification, have influenced these countries' approach to energy production and the enabling of policies and regulations. Within this renewable energy (RE) policy landscape lies the contentious issue of social acceptance of wind power. We contribute to discussions of social acceptance of RE by proposing the development of an analytical framework that addresses the interactions between actors at different scales of the energy and planning sectors. The reasoning is to be able to identify those dynamics that are potentially counterproductive to the energy transition and need further policy emphasis, as well as supporting those that demonstrate a positive impact. This framework analysis reveals for each country very similar policy profiles, characterised by a heavy focus on the Market dimension at all scales, an effort to allow private business to steer the transition, and a very low focus on the Community dimension. In doing so, our research reveals how policy-making processes have privileged the voice of actors who are able to communicate quantifiable data and evidence to support their position and influence energy policy debates.

3.1 INTRODUCTION

3.1.1 Energy modelling, planning, and social acceptance

Many countries have embarked on a transition to low-carbon energy systems, primarily motivated by the twin imperatives of greater energy security and climate change mitigation. In the case of EU Member States, this transition is influenced by the European Parliament's vision. In 2009, the EU published the Renewable Energy Directive in an effort to reduce CO_2 emissions. In 2010, Member States submitted National Renewable Energy Action Plans (NREAPs) that outlined their current and upcoming policies to increase their share of renewable energy (RE) and reach the Directive's target of 20% of electricity from RE (Council of the European Union, 2009a). Such national energy strategies are informed by large-scale models which seek to address sustainability and climate change goals (Pfenninger et al., 2014) based on the current understanding of available resources, technological development and financial viability of different forms of energy infrastructure. As such, energy modelling has become an essential activity that allows policymakers and investors to react to environmental realities by testing the introduction of new technologies within an existing mix, as well as the efficiency and impacts of proposed policies intended to accelerate the diffusion of new technologies. So-called 3E (energy, environment, and economics) models are typically linear optimisation models and provide the least-cost solution for a future energy system that meets the projected future energy demand subject to the constraints (e.g., carbon budget) and assumptions (future cost curves) given exogenously. At the national level, these models are generally operated by national energy agencies or ministries (or, alternatively, by other experts on their behalf), who will advise governments in the setting of national targets and supporting policies.

Any targets that may emerge from national energy strategies then rely on other policy instruments, including fiscal tools and spatial planning to stimulate and regulate implementable projects. Spatial planning has particular relevance here, as it is the process that translates the targets into meaningful phenomena at the community level; hence, it is at local spatial planning level that modelling results are actually reified into tangible outcomes experienced by the population.

Researchers in social acceptance (Haggett, 2013; Horbaty et al., 2012) have emphasised that increased participatory processes and better understanding of local dynamics are necessary in order for populations to better understand global macro visions of large-scale RE deployment and to accept the effects on their local communities. Indeed, the vast majority of macro-level techno-economic modelling tools cannot yet take into account local political and community preferences or dynamics. Therefore, social acceptance researchers have been focusing on energy and planning policies as a point where actors and dynamics observed to shape social acceptance could be further considered by decision makers (Arnstein, 1969; Jasanoff, 2018).

This paper aims to contribute to this research on the influence of policies on social acceptance by proposing the development of an analytical framework that addresses the interactions between actors at different scales of the energy and planning sectors. The reasoning is to be able to identify those dynamics that are potentially counterproductive to the energy transition and therefore need further policy emphasis, as well as supporting those that demonstrate a positive impact. We discuss below the European context of RE global and national targets and the particular difficulties raised by onshore wind power, before detailing our proposed analytical framework in section 3.2.1 and applying it to three wind-rich case-study countries in section 3.4: Denmark, Ireland and the UK. Finally, we discuss in section 3.5 our aggregated results in a more general EU context and their implications for further wind power deployment.

3.1.2 Wind energy and social acceptance

Wind energy is a crucial renewable source for Europe. This is reflected in the EU's RE Directive (Council of the European Union, 2009a) and, consequently, the Member States' NREAPs. Wind energy has one of the lowest life-cycle assessments among energy sources (IPCC, 2012), onshore wind has one of the lowest levelised costs among renewables, the cost of offshore wind has decreased rapidly (IEA, 2015) and Europe benefits from numerous places with wind characteristics adapted to harnessing the resource (European Environmental Agency, 2009). Onshore wind is currently the second largest renewable electricity producer in Europe after large hydropower, which has reached its full potential (European Commission, 2017). Given that the hub heights of wind turbines gradually increase as the technology matures, and that the powering-down effect of turbulence decreases with altitude, there are good technological prospects for continued improvements in turbine efficiency and output from onshore windfarms (Twidell et al., 2015).

However, wind energy, even at large power capacity, has a low power density per unit of surface area, and thus requires large tracts of land or off-shore seabed to become a substantial part of national energy portfolios (Smil, 2010). Even with regular improvements to the technology, the land requirements, combined with policies setting advantageous financial support for developers in several EU countries, have left spatial planning departments to deal with rapidly growing numbers of wind power projects for which they have had to comprehensively assess impacts and feasibility (Haggett, 2013). This has often been undertaken in an adversarial context that has left both developers and host communities dissatisfied, with the former often complaining about the negative effect of delay and uncertainty on investors, and the latter regularly concerned about the visual and distributive impacts resulting from wind energy projects. The translational process from RE targets to implementable wind energy projects has therefore met a range of barriers and triggered strong opposition movements among communities across Europe (Bell et al., 2013; Ellis et al., 2009; Haggett, 2010; Jolivet and Heiskanen, 2010; Toke et al., 2008).

Denmark and the UK have recently distanced themselves from onshore wind power in favour of offshore resource exploitation, officially citing the impacts on local populations (Danish Coalition, 2018) and the failure to secure public acceptance (British Conservative Party, 2015) as explanations for their decisions. Given the importance of onshore wind to the NREAPs, the cumulative effect of such issues has reduced overall capacity of this technology and could have significant consequences for national low-carbon energy strategies.

3.1.3 Frameworks for social acceptance

A number of frameworks have been proposed to help understand the complexity of social acceptance and its drivers. For example, Wüstenhagen et al. (2007) suggested that social acceptance of renewable energies is shaped by three dimensions – market, socio-political and community – thus distinguishing a universal and homogenising sense of acceptance (often represented by 'positive' national opinion polls) from its representation in policies and the varied reaction of local communities. A second observation was the lack of clarity, mainly within the market sector's outgoing communication, which kept the community level from fully grasping the extent of the energy transition orchestrated in most countries by the market and socio-political dimensions (Wüstenhagen et al., 2007). Sovacool and Lakshmi Ratan (2012) elaborated on Wüstenhagen et al.'s (2007) model by developing the three dimensions into nine factors that "create conditions where socio-political, community, and market acceptance of renewable electricity technologies will occur". They listed the sub-criteria shown in Table 8 with the purpose of better guiding the assessment of an energy system and its openness towards a selected technology.

Dimension	Specific factors		
Market	Competitive installation/production costs	Mechanisms for information and feedback	Access to financing
Socio-political	Strong institutional capacity	Political commitment	Favourable legal and regulatory frameworks
Community	Prolific community/individual ownership and use	Participatory project siting	Recognition of externalities or positive public image

Table 8 Description of Sovacool and Lakshmi Ratan's (2012) framework, Source: (Sovacool and Lakshmi Ratan, 2012)

Fournis and Fortin (2017) also developed a framework similar to Wüstenhagen et al.'s by introducing scalar aspects through examining the "collective choices that determine the articulation between technology and society within a specific territory" and discussing the idea of developing the acceptability of technologies, instead of seeking acceptance (Fournis and Fortin, 2017). They built a framework focused on wind power and based on Szarka's (2007) concept of social acceptability, adding political and decision-making processes as key factors shaping the degree of acceptance within each dimension/scale: macro, meso and micro (Ellis et al., 2009; Szarka, 2007).

The rationalities operating the macro scale relate greatly to that of the market dimension characterised by competition, innovations influenced by investment trends and path dependency (Szarka, 2007). Usual actors are developers, manufacturers, national to supra-national political authorities and banking institutions (Lewis and Wiser, 2007), now evolving in a context of market globalisation (Fournis and Fortin, 2017; Huber, 2008). The meso level relates to decisions made by local authorities (e.g., project planning consents) and preferences indicated in national energy policies, thus relating to the socio-political dimension. Common actors are policymakers and authorities holding powers of energy governance (Breukers & Wolsink, 2007; Ellis et al., 2009c; Toke & Strachan, 2006). The micro level focuses on the individuality that identifies each person's perception of wind energy, and thus relates to the community element. Its actors are the individuals who ultimately form the aggregated local opinion towards disinterest, opposition, or support, and follow rationalities of cost or benefits of projects for local populations, public health, and place attachment (Batel and Devine-Wright, 2015; Devine-Wright, 2013b).

While this does provide us with a useful conceptual frame to understand the complexity of social acceptance/acceptability, it is still unable to capture the whole range of interactions between actors and differing scales. Indeed, in a recent review conducted for the European Commission, Ellis and Ferraro (2017) highlighted some of the limitations of social acceptance research and recommended further research with cross-scalar and dimension perspectives (Ellis and Ferraro, 2016), with similar points also being made by Devine-Wright et al. (2017b). There is therefore a clear need to improve our understanding of scalar interactions within RE deployment, which would contribute to identifying opportunities to create more innovative responses to the challenge of social acceptance.

Given the role and importance played by energy policies with regard to national planning, there is a need to increase understanding as to how social acceptance issues are captured and expressed. By failing to develop more holistic practices, we risk continually studying isolated cases that, even taken in aggregate, are of limited value for informing policies at the national level. This is because they fail to describe the broader and multifaceted picture of national energy systems, and it is difficult to synthesise these disparate studies into a cohesive picture at the national scale where energy policy is made.

Therefore, this paper aims to contribute to the development of an analytical framework that better incorporates the scalar interactions of social acceptance by expanding the description of the three common dimensions – market, socio-political and community – across societal scales. The framework is then used to explore the interplay between the different scales by examining how social concerns are integrated in NREAP policies in three wind-rich European countries – Denmark, Ireland and the UK – and from this, it draws implications for future deployment of wind energy in Europe. These aims are summarised in the following three main questions driving the study:

1) How is social acceptance articulated and responded to in National Renewable Energy Action Plans – i.e., at the macro scale?
2) What are the interactions between sectors and scales?
3) What are the implications for future policies and the deployment of wind energy in Europe?

3.2 Research approach

3.2.1 Analytical framework

The plurality of scales at play within each dimension is illustrated in Figure 10, where each of the three levels previously identified (see section 3.1.3) – community, market and socio-political – is displayed with actors operating at the different scales 1, 2 and 3, or macro, meso and micro. By including these three scales, the notion of national public acceptance, which Wüstenhagen et al. (2007) initially associated with the socio-political dimension, shifts to the macro scale of the community dimension, which represents the national identity or popular perception of energy (see framework description in Table 10). With this shift, the socio-political dimension becomes solely focused on matters of acceptance expressed by authorities – for example, expressions of political support towards a green agenda or planning policies. To reflect this adjustment of the framework, we rename the initial socio-political dimension as the ‘political-regulatory’ dimension. This change will be reflected from this point forward in the article.

By addressing the research questions for NREAP policies, our article aims to develops this symbolisation into a more accurate portrayal of the current dynamics (display proposed in Figure 17 as part of the discussion).

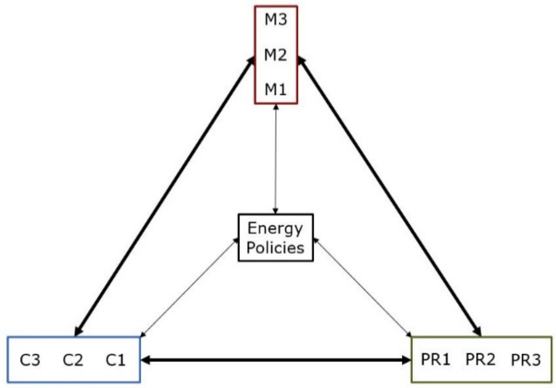

Figure 10 Analytical framework: representation of dimensions and scales of social acceptance. The numbers 1, 2 and 3 represent the macro, meso and micro (local) scales, respectively. The double arrows between each dimension represent the multiple connections between scales, dimensions and policies

3.2.2 Case studies

The preliminary case study approach consists of the descriptions of national energy policies in the National Renewable Energy Action Plans (NREAPs) of Denmark, Ireland and the UK. These three countries are analogous in that they have some of the highest resources of wind energy potential in Europe. This includes having with some of the highest amounts of wind energy full-load hours,[9] as calculated by the European Energy Agency on average wind speeds and distributions at heights of 80 m onshore and 120 m offshore (European Environmental Agency, 2009, pp. 23–24). Since the appearance of the first turbines connected to the grid and the development of the sector into a large-scale manufacturing activity, this abundance of wind has helped shape the countries' energy sectors, otherwise mostly based on fossil and nuclear energy in the case of the UK and Ireland. Some of the countries' main policies in the past 10 years have been aimed at wind power, such as the Renewable Energy Agreement in Denmark in 2009, the Renewables Obligation Certificates (ROC) in the UK in 2002, and Renewable Energy Feed-in-Tariff (REFIT) in Ireland.

In line with their initial ambition to harness the wind resource, the three countries are signatories to the EU 2009 Renewable Energy Directive (Council of the European Union, 2009a) and, as such, provided their NREAPs in 2010. NREAPs detail how each country is planning to reach its

[9] Full-load hours represent the time per year that a wind turbine in a particular location produces at full load.

national targets set by the Directive according to the country's RE potential and agreed by the countries themselves. The basic requirements set by the Directive insist on harmonised values of expected final energy consumption and sectoral 2020 estimated shares of energy from renewable sources in electricity, heating and cooling, and transport. It also requires basic descriptions of the measures and policies set to reach those targets, with a focus on biomass and transfers across Member States. The requirements are not particularly specific and no details were required concerning the means that each country would develop to increase social acceptance. The NREAP targets are legally binding, but the Directive does not give specific details as to what level of sanctions would be imposed on countries that fail to reach their target by 2020.

Matters of declining social acceptance of RETs in Denmark, Ireland and the UK, and social opposition to wind power in particular, have increasingly led to delays and cancellations of specific projects (Haggett, 2010). For Denmark, among other factors, these matters have led the government to opt for an energy agreement to create a liberalised energy market (Danish Coalition, 2018), while in the UK, onshore wind power is no longer financially supported by the Contracts for Difference bidding scheme launched in 2014 (HM Government, 2014). In Ireland, concern about the impact of large scale wind energy on the landscape and the lack of community engagement (Lennon and Scott, 2015; SLR Consulting et al., 2014) has led to the government suggesting that it needs to foster 'energy citizens' (Department of Communications Energy and Natural Resources, 2015).

3.3 Methodology

As a first step of this research, the NREAP policies were coded inductively, and 46 codes were generated through close reading to describe each policy's content and purpose. In line with the inductive approach, new codes were created as we read through each policy document. Therefore, to ensure a comprehensive use of the entire code list over the three policy documents, two more iterations were conducted with the final code list. Each code produced was then associated with level(s) of social acceptance as per the existing literature (Fournis and Fortin, 2017; Wüstenhagen et al., 2007). Codes describing a technology were grouped separately. Several codes were assessed as having linkages with two or three levels, and as a result, we have the following groups:

- Technology (this is included to emphasise the discussion in section 3.5, showing onshore wind as the most important RE technology in the three case studies)
- Market
- Market / Political-Regulatory

- Political-Regulatory / Community
- Community
- General (can be linked to the three dimensions of social acceptance)

The codes, their overall occurrences and the group to which they were linked are displayed in Table 9.

Technology		Market		Market/Political-Regulatory		Political-Regulatory/ Community		Community		General	
CCS	1	Energy export	1	Energy demand	1	Environmental impact	4	Social costs	2	Behaviour change	25
Geothermal	1	Energy system costs	1	Sectors/sectoral	1	Population public behaviour	4	Interaction with local population	5	Incentive	40
CHP	4	Production costs	1	CO_2 emissions and targets	2	Dissemination	6				
EVs	4	Resource constraint	1	Service sector	2	Social benefits	7				
Electric Heating	9	Resource import	1	Device's geographical location	3	Buildings residential	14				
Hydro	10	Resource prices	1	Infrastructures	4	Local authorities	18				
Transport	10	Carbon tax	2	Energy targets	7						
Wave Tidal	11	Fuel costs	3	RE policy & support	12						
Biofuel	13	Industry sector	3	Efficiency measures	17						
Offshore Wind	16	Technology costs	7								
Solar	18	Grid	9								
Biomass	21	Energy producers	15								
Onshore Wind	35	Investments (costs)	29								
		Technology development	30								

Table 9 Codes grouped by dimensions of social acceptance

In a second step, the operative or target scales of each policy were identified according to the information and descriptions of the policies given by the NREAP documents, and coded 1, 2 or 3, as described in the proposed framework in Table 10.

Thus, combining the dimensions and scales identified, each policy was coded with at least one of the following groups:

- Community: C1 C2 C3
- Market: M1 M2 M3
- Political-Regulatory: PR1 PR2 PR3

	MACRO 1: Global → National	MESO 2: National → Regional	MICRO 3: Regional → Local
COMMUNITY C Social acceptance Reasons for opposition/support Trust towards institutions and actors Distributional and procedural justices Individual perceptions of technologies Aggregated public opinion Cost/benefits for local populations Public health	National energy identity or culture Popular perception "Zeitgeist" National opinion polls	Participatory processes Interaction between local authorities/communities Energy cooperatives	Place attachment Standardised impact studies Social mediation Public engagement Opposition Remoteness from decision-making process and places Interest for micro RE Disruption, visibility, smell and sound levels Property ownership
MARKET M Tendering, competition, adaptability R&D, innovations Investments and path dependency Green power marketing strategy	Globalisation, internationalisation strategy National and international opportunities Move to offshore wind Lobbying, influence of companies on policies Funding of R&D Business incentives Support investment Aggregated production/demand Modelling Tax targets	National interests Monopolies on regional grids Modelling Control access to grid Existing national energy production and infrastructures Green power marketing	Move to offshore wind Increasing scale of onshore wind Information meetings Increasing surface of solar and biomass Local employment
POLITICAL-REGULATORY PR Policymakers Reliable financial system Collaborative spatial planning system Governance Decision-making mechanisms Legal framework Articulation of interests and strategies	National policies Assumptions on behaviour change National political support EU strategies Expressions of political support for RE at national scale	Local authorities Institutionalisation of frameworks that foster market and community acceptance Planning policies Invoking participation Consultation Strategic planning National strategy in regional context Expressions of political support for RE at regional scale Actions of local authorities	Siting decisions Compensation measures Local, regional elections

Table 10 Dimension/Scale policy analytical framework

3.4 NATIONAL-LEVEL RESULTS AND DISCUSSION

The following sections discuss the outcomes of the framework analysis in the context of each country's energy system and policy evolution, before reflecting on implications for future policies. The focus is on the period since the launch of the EU Directive in 2009, the adoption of NREAPs in 2010 and the progression up to the present; however, we also build on the countries' recent energy histories and major decisions that have shaped their respective energy systems.

3.4.1 Denmark

Denmark endeavours to have its heating and electricity sectors fossil-fuel free by 2035 and to be completely fossil-fuel free by 2050. The Danish Energy Agency depended heavily on economic optimisation energy modelling to create pathways for meeting the ambitious targets for the future energy system (Andersen and Termansen, 2013).

To support these targets, the Danish Energy Agency modelled different scenarios for the years 2020, 2035 and 2050, stating that "the scenarios form a common background for the analyses that were launched with the energy agreement of 22 March 2012" (Danish Energy Agency, 2014). Four of the modelled scenarios were used to compare different strategies for achieving independence from fossil fuels, while one scenario represented a baseline, least-cost, fossil fuel-based energy system. While all scenarios included improvements in energy efficiency and a limited amount of solar power, the scenarios generally varied between electricity-based strategies and fuel-based strategies.

In particular, the wind scenario describes a strategy that requires large-scale electrification of the transport, heating and industrial sectors. To achieve independence from fossil fuels, wind capacity would need to be expanded by 400 MW annually between 2020 and 2050. The hydrogen scenario incorporates even more wind than the wind scenario, thus requiring an even more accelerated expansion of wind power. This expansion is assumed to be largely sited offshore, and aging onshore wind turbines would need to be replaced under this scenario.

Despite those official scenarios forecasting a continued increase in onshore wind, the Danish NREAP instead planned a decrease in onshore and overall wind capacity, suggesting that Danish authorities considered that a threshold had been reached and the theoretical higher potential of onshore wind power (Energinet.dk, 2015) would not be pursued. Even with this imposed limit for onshore wind, Denmark is still in line to reach its NREAP targets of RE covering 20% of the country's gross energy consumption by 2020 (European Commission, 2015b).

The conflicting plans described above correspond to the period when the NREAP was introduced in 2010, and this ambivalence is indeed perceivable through the Danish NREAP policies. The results of the framework analysis for Denmark presented in Figure 14 and Figure 15 show an efforts towards C3, local community acceptance, in the form of two policies that address common acceptance issues: the option to purchase wind farm shares addresses complaints of unfairness towards the local inhabitants who experience the presence of turbines on a daily basis but do not financially benefit from them, and a compensation plan addresses complaints regarding a decrease in property values claimed to be the result of a wind farm being built in the vicinity (Anker and Jørgensen, 2015). The erosion of public acceptance targeted by those two policies and the overall 2008 Promotion of Renewable Energy Act of which they were a part corresponds to the collapse of the wind cooperatives in Denmark in the early 2000s, and their replacement by large-scale wind farm developers and owners (Hvelplund, 2006; Wierling et al., 2018).

These policies and the Promotion of the Renewable Energy Act represented a first in terms of local financial involvement through policies, yet the overall NREAP focus on the community dimension remains low compared to that of market-focused policy incentives. The coding visualisation in Figure 15 highlights the high focus on the market sector at both national (M2) and local (M3) scales, with a particular emphasis on supporting the local supply chain of biomass resources.

In this visualisation, we can also observe the code C2 for Denmark, which represents policies aimed at including local energy producers, such as farmers and cooperatives, in some of the support schemes more generally aimed at the market sector (M2 and M3). Figure 11 further highlights how these dynamics between local energy producers (C2) and the market levels (M1, M2 and M3) were particularly promoted by the NREAP plans, as well as between the three market levels. Those interactions suggest a marked intent to open incentives to varied business sizes, ensuring that local producers and suppliers were able to benefit from the financial advantages set by the RE targets, thus securing some form of acceptance of future RE plans through local businesses (M30 and, to some extent, C2.

Yet, this C2 and M3 involvement is now likely to change, at least for local wind and solar PV producers, with the enactment of the new Energy Agreement in June 2018, which officialises the plan of strictly decreasing the number of onshore wind turbines. It plans to do so by establishing a strict reduction plan, which sees the forced interruption of new turbine supply if the plan is not followed satisfactorily. Furthermore, the main change consists in the introduction of a new bidding system whereby developers (onshore and offshore wind and solar PV) have to bid for the lowest possible electricity sale price (Danish Coalition, 2018). This move is likely to limit wind cooperatives' access to the medium-scale turbines they could usually afford, and prioritise large corporate actors of the wind sector (M1) (Wierling et al., 2018). The future Danish wind sector will thus comprise offshore sites and a limited number of large-scale onshore installations. Besides the decreasing costs of offshore wind (IEA, 2015), the main motivation cited in the Energy Agreement for this new strategy are the inconveniences felt by the local community (C3) near wind farms and the impact on their properties.

As previously mentioned, we note that focus on C3 was relatively low in the NREAP policies, with, for example, no mention of policies targeting employment opportunities (the topic is briefly mentioned in the overall NREAP), which are known to generate community support towards the industries bringing employment (Hvelplund et al., 2012; Lund, 2014). Additionally, the efforts put towards creating dynamics between C2, M3 and the overall market sector in the NREAP now seem in jeopardy in the new bidding context for local onshore wind and solar PV producers.

This evolution is also perceived through changes made to the political-regulatory sector. In an effort to concede more involvement to municipalities (PR3), siting authority was transferred to local municipal authorities (Krohn et al., 2002). They then often pursued a "conflict-avoidance" strategy and, along with scrappage incentives, the move was made in favour of fewer, larger turbines, placed away from residents (Sperling et al., 2010). This organisation is further established in the NREAP with a relative focus on PR3, as encouraged by the EU Directive (Council of the European Union, 2009a), and the effort to distribute energy governance is perceivable. Under the new Energy Agreement, municipalities will retain this authority, but the ultimate decision on the bidding proposals (which will have to have previously secured planning permission) will be centralised to the Danish Energy Agency at PR1 level.

	C1	C2	C3	M1	M2	M3	PR1	PR2
C2	0							
C3	0	0						
M1	0	3	0					
M2	0	4	0	6				
M3	0	5	1	0	8			
PR1	0	0	0	0	0	0		
PR2	0	0	0	1	0	0	0	
PR3	0	0	1	0	0	0	0	0

Figure 11 Co-occurrences in the Danish NREAP, highlighting interactions between two codes within a same policy

The recent evolution of the Danish wind sector shows the discreet but growing impact of the community dimension on national decisions. Indeed, when the supporting community (C3 and

C2) environment deteriorated due to increasing turbine sizes and the proliferation of company-owned wind farms (Borch et al., 2017), the discontent expressed to local authorities in charge of spatial planning eventually reached the level of national political parties, who decided to act by avoiding the issue and prioritising offshore wind. Looking at this context in the light of the present NREAP policy analysis, the high policy focus on market implementation, even if purposefully stretched to local businesses (M3) and citizen producers (C2), was not sufficient to ensure a constructive dialogue between the community and authorities beyond the opposition voices, as illustrated in Figure 11 by the lack of interactions between authority (PR) and community (C) elements.

3.4.2 Ireland

Ireland has 2020 targets of reducing non-ETS emissions (relative to 2005), through a 20% saving in energy consumption and achieving 16% of national energy supply from renewables, including 40% of energy generation (SEAI, 2016). These targets were agreed in the EU Directive 2009/28/EC, and the pathways for achieving the targets are set out in Ireland's NREAP (*National renewable energy action plan Ireland*, 2010). This NREAP used demand forecasts from SEAI (2009) (Clancy et al., 2010) and gross final consumption estimates based on the output from the Economic and Social Research Institute of Ireland's macroeconomic model for Ireland: HERMES (FitzGerald et al., 2002). The NREAP set out a number of pathways for achieving these targets, with large-scale onshore wind making a major contribution to the 40% renewable target, heavily dependent on a strengthening of the transmission system across the island of Ireland. Subsequent to the publication of the NREAP, the Environment Research Institute, University College Cork, developed an energy-systems optimisation model – the Irish TIMES model (Gallachóir et al., 2012) – which facilitated the development of alternative pathways for the achievement of Ireland's energy targets, provided a reassessment of policies for renewable energy and explored the implications of potential higher emissions targets.

These projections have been continually reviewed by the Sustainable Energy Authority Ireland (SEAI), which advises the government on issues related to energy and the transition to a low-carbon economy. It has established an Energy Modelling group and regularly publishes progress reports on achievement of targets (SEAI, 2016) and revised projections (SEAI, 2017).

This led to a range of support mechanisms for wind development, based on the feed-in-tariff model and supported by a Wind Energy Roadmap (Clancy et al., 2010), which speculated that with favourable developments in policy and infrastructure, Ireland had the potential to develop an export-driven wind market by 2030, amounting to 2.5% of all EU electricity demand and the country contributing 5% of Europe's entire wind energy generation. The baseline scenario of this 2010 roadmap report is presented as a benchmark to evaluate the impacts of the policies presented as part of the NREAP plan and targets published in the same year (Clancy et al., 2010, p. 3). The roadmap was heavily influenced by economic projections and assumptions of infrastructure development, and while public engagement is acknowledged as an issue, it is treated as a background facilitator rather than a constraint on the deployment of wind energy projects. The framework analysis we conducted on the NREAP policies (see Figure 10) indeed shows that the level of focus on the public influence (C3) within the NREAP was similarly treated as a minor element compared to the share of policy focus given to market actors at all scales (M1–3).

Reflecting this policy focus on supporting the market sector, this roadmap led to a rapid expansion of large-scale wind projects, followed by a growing sense of opposition from host communities (C3). This situation triggered very little response from the wind industry and the government, exemplified by the lack of updates on outdated planning guidelines published in 2006. The NREAP policies coded PR2–3 addressed the need for planning guidelines able to support RE development, although, as of 2017, revised planning guidelines were still in draft forms. Such lack of concrete response while wind farms get built creates a loop of growing dissatisfaction directed at both authorities (PR1–3) and the industry (M1–3). This struggle to bring forward concrete plans to regulate developments and address public concerns, associated with minimal policy support for community-owned energy projects (C2), convey an image of passive authorities predominantly in support of corporate actors (M1–2) and unresponsive to community developments and concerns.

Looking at the levels of focus on the community dimension, there is no mechanism to address the impacts of RE projects once built, as implemented in Denmark (see section 3.4.1), but two policies address the need for dissemination of information on renewable energy to the public (C3). Concerning the support for locally owned projects (C2), Figure 14 and Figure 15 show that it is proportionally lower than in the sets of policies within the British and Danish NREAPs.

Concerning the interactions supported by the NREAP policies and displayed in Figure 12, the most frequent connections are similar to those observed in the Danish and British policy sets among market levels M1–3. However, while the Danish and British NREAPs displayed significant focus on connecting local project developers (C2) with market-supporting policies, this connection appears much lower in the Irish case.

Following the 2010 roadmap and NREAP analysed here, the situation of growing local discontent (C3) appeared to reach a crisis point in 2013, which witnessed an increased level of political activity around opposition to onshore wind (e.g., through a private members bill seeking to extend setback distances) and an extremely negative reaction to the first major proposal for wind energy for export. This was a 3000 MW project proposed for the Irish Midlands, which would solely serve the UK energy market, and would hence be part of the M1 category. This fact, coupled with the rather audacious attitude of the developer, led to a major acceptance crisis that, for a while at least, appeared to make the whole wind energy sector toxic (see Lennon & Scott, 2015).

This in turn prompted a deeper reflection within the government, which responded with an energy white paper (in 2015) that recognised the social dimension of the energy transition and acknowledged that this could not be secured without the engagement of 'energy citizens' (C3), a term coined in the white paper to mark these efforts to involve the population within energy plans (Department of Communications Energy and Natural Resources, 2015). While this is yet to be translated into new legislative measures, meaning that it is not yet known what form of support towards C2 and C3 will be proposed, its influence has been felt in the revision of the Energy Support System. Indeed, any proposals in 2019 will now be required to offer a proportion of ownership of new renewable projects to local communities (C3), based on the Danish model's Option to Purchase Shares Scheme (Anker and Jørgensen, 2015).

	C1	C2	C3	M1	M2	M3	PR1	PR2
C2	0							
C3	0	2						
M1	0	1	0					
M2	0	3	1	10				
M3	0	3	1	4	9			
PR1	0	0	0	3	2	0		
PR2	0	1	1	3	6	2	3	
PR3	0	2	1	0	2	3	0	4

Figure 12 Co-occurrences in the Irish NREAP, highlighting interactions between two codes within a same policy

3.4.3 United Kingdom

A variety of integrated assessment models have contributed to the shaping of the British energy system – from the 2008 first Carbon Budget covering 2008–2012 to the fifth, and latest, 2016 edition covering 2028–2032. It was also previously shaped by a series of Energy White Papers. The Department of Energy and Climate Change[10] (DECC) and the University College London Energy Institute, both affiliated to the ETSAP-TIAM modelling network, collaborated with the ETSAP range of models such as UK MARKAL, TIAM-UCL and the latest version, the UK

[10] The DECC became part of the Department for Business, Energy and Industrial Strategy in July 2016.

TIMES model (Department of Energy and Climate Change [DECC], 2011; UCL Energy Institute, n.d.).

In 2010, the introduction to the UK NREAP document stated the country's need to radically increase RE production as it "had been blessed with a wealth of energy resources" (DECC, 2009, p. 4). Following this statement, the UK stated its target of a 31% share of renewable energy production by 2020 (DECC, 2009, p. 12) and its main supporting policy tools: the Renewable Obligation (RO) scheme, the Feed-In Tariff (FIT) scheme, and the Renewable Heat Incentive (RHI) (DECC, 2009, pp. 15–16). However, since the publication of the NREAP document in 2010, the UK has experienced a period of intense political change, which has resulted in strong alterations to the country's energy policies.

The government announced in 2014 that the overall RO[11] scheme would end in March 2017 (DECC, 2009; HM Government, 2014), but onshore wind would stop in April 2016 (Ofgem, 2017). These decisions constituted parts of the government's plan to end subsidies for renewable technologies that it considered mature. The RO scheme was replaced by the bidding system "Contract for Difference" (CfD), where developers compete to submit the lowest installation price and acquire a 15-year contract (Department for Business Energy and Industrial Strategy [DBEIS], 2017; Department of Energy and Climate Change [DECC], 2014). A precedent to the Danish bidding system discussed in section 3.4.1, this prioritised corporate actors (M1) with economies of scale, as opposed to smaller local businesses (M3) and cooperative organisations (C2). Meanwhile, our analysis highlights that the 2010 NREAP was significantly market focused (see Figure 14 and Figure 15), although with a stronger emphasis on the involvement of smaller businesses (M2 and M3) in the RE sector in general. The first round of CfD auctions took place in 2014 and included all renewable technologies present in the UK, while the second round, in April 2017, did not include any capacity of onshore wind (DBEIS, 2016a).

In August 2015, the government announced that the Feed-In Tariff scheme,[12] a key policy for local energy producers and cooperatives (C2), would see its prices reduced and the scheme finally closed down in January 2016 (DECC, 2015). Faced with strong opposition from both actors of the market sector (M1—3) and C2 (DECC, 2015, p. 6), the scheme was retained but with heavily

[11] It rendered it compulsory for electricity providers to deliver, each year, a given amount of Renewable Obligation Certificates (ROCs) that are acquired from RE production or purchases. The amount given per kW depends on the technology. This allowed the government to follow the evolution of the energy market and prioritise selected technologies (Department of Energy and Climate Change, 2010).

[12] The scheme guarantees a fixed price for renewable electricity fed into the grid, depending on the type of technology and the capacity up to 5 MW (DECC, 2009, p. 15).

limiting measures added.[13] The third policy, the Renewable Heat Incentive (RHI),[14] also partly aimed at and supportive of prosumers (C2), was also threatened with early closure for solar thermal. Reactions to the consultation (DECC), 2016) showed significant public and stakeholder support for this technology from C2 and market actors, and the tariff was maintained at the same level (DBEIS), 2016b, p. 32).

Thus, in both those cases where authorities had a legal duty to consult on policies (HM Government, 2008), significant public and stakeholder (C2 and M1–3) reactions altered official plans of early policy modification or closure. These reactions illustrate the interest from stakeholders, including prosumers (C2), to engage in the energy sector and take advantage of support incentives, but it also demonstrates that such involvement requires a certain level of regulatory stability. This engagement comes despite low levels of interaction created through policies between prosumers (C2) and M/PR elements, as observed in Figure 13, suggesting that those dynamics and C2 engagement, which support energy transition, are not being adequately explored and/or supported by policies.

In fact, while the 2014 share of 17.8% of electricity produced from renewables (European Environmental Agency, 2017, p. 23) is in accordance with the 2010 plan of doubling the share by 2020, the 2015 progress study by the EU Commission expected the UK to have difficulties in reaching its targets and recommended a review of its energy policies (European Commission, 2015b, p. 5). The International Energy Agency also considers that the sudden changes of energy policies is creating uncertainty and is decreasing the country's attractiveness among investors (International Energy Agency, 2018).

The decisions concerning onshore wind discussed above were announced in the ruling Conservative Party's 2015 manifesto, citing the fact that "onshore windfarms often fail to win public support" at C3 level as a key reason for the decision (British Conservative Party, 2015, p. 57). Concerning community acceptance at C3 level, the British NREAP back in 2010 presented two policies aimed at supporting dissemination of information to the local community (C3) regarding RE projects: "Information/Ad campaigns" targeted "public consciousness" and intended to motivate "the public to act on climate change through take up of renewable energy", while GPWind – good practice in reconciling wind energy with environmental objectives and community engagement – aimed to gather information on wind power from Member States to

[13] Caps on quarterly registered capacity in each renewable technology, the reduction of all tariffs, the re-introduction of pre-accreditation rules (previously ended after earlier consultation), planned degression, and an additional contingent degression when a cap is reached [23].

[14] Was not yet in force at the time of publication of the NREAP and was proposed to commence in April 2011 depending on ministerial approval (DECC, 2009, p. 16).

"positively address environmental issues and the concerns of local communities" (DECC, 2009). Assessing the impacts of those two policies would require a detailed analysis of the means committed; however, since the British ruling party cited issues of low C3 acceptance as the official reason for halting subsidies for onshore wind, this would point to a partial failure of these two policies aimed at increasing awareness. Put in the context of the overall set of NREAP policies, as displayed in Figure 14 and Figure 15, we observe that those two policies are the only tools aimed at the micro scale of community (C3), besides financial incentives targeting prosumers (C2). Furthermore, we observe in Figure 13 that those two C3 policies do not engage any of the interactions otherwise created by the UK NREAP. Since C3 was a key governmental concern, we assume that the British government had a deeper understanding of the situation and the means that should be allocated to those two policies. Yet, their seemingly negative outcome suggests that more consideration ought to given to adapting community-focused policies to their actual target and its characteristic diversity, instead of relying on 'one-size-fits-all' policies with general wording and purposes. Furthermore, rather than stand-alone C3 policies (as illustrated by Figure 13), they could benefit from better integration to already established policy-induced dynamics.

In terms of the political-regulatory dimension, it is mainly addressed for the alleged necessity of further structuring planning guidelines towards the facilitation of RE project development. Planning rule adequacy is one of the areas on which the EU Directive asked all Member States to add focus prior to releasing NREAPs. In the case of the UK, this request came at the same time as the publication of a discussion among experts in the field of planning research regarding whether planning was actually the cause of the alleged difficulties experienced by developers in gaining planning consent for wind farm projects. These experts argued that planning authorities had actually been fulfilling their duties as per official guidelines, and they voiced their concerns over "the way that the concept of sustainability has been used over the last decade to justify pro-market solutions through the planning system" (Ellis et al., 2009). It is debatable, seeing the heavy market focus observed in the NREAP policies, evolving towards more opportunities for large businesses (M1), and the limited emphasis on PR and C, whether this warning was fully comprehended by the current authorities.

	C1	C2	C3	M1	M2	M3	PR1	PR2
C2	1							
C3	1	2						
M1	0	0	0					
M2	0	2	0	6				
M3	0	3	0	2	8			
PR1	1	1	1	0	0	0		
PR2	0	0	0	0	6	0	0	
PR3	0	1	1	0	4	2	0	6

Figure 13 Co-occurrences in the UK NREAP, highlighting interactions between two codes within a same policy

3.5 Aggregated results and Discussion

In the findings from each country, we particularly observe that the micro and meso, or local and regional, scales of the market dimension are the main focus of the policies in each case-study country.

	C1	C2	C3	M1	M2	M3	PR1	PR2	PR3
Denmark	0%	18%	4%	16%	28%	23%	0%	4%	9%
Ireland	0%	5%	4%	18%	27%	19%	6%	14%	8%
UK	1%	9%	3%	9%	30%	22%	1%	13%	12%
Total	0%	10%	3%	14%	28%	21%	3%	11%	9%

Figure 14 Distribution of scale and dimension targets among NREAP policies

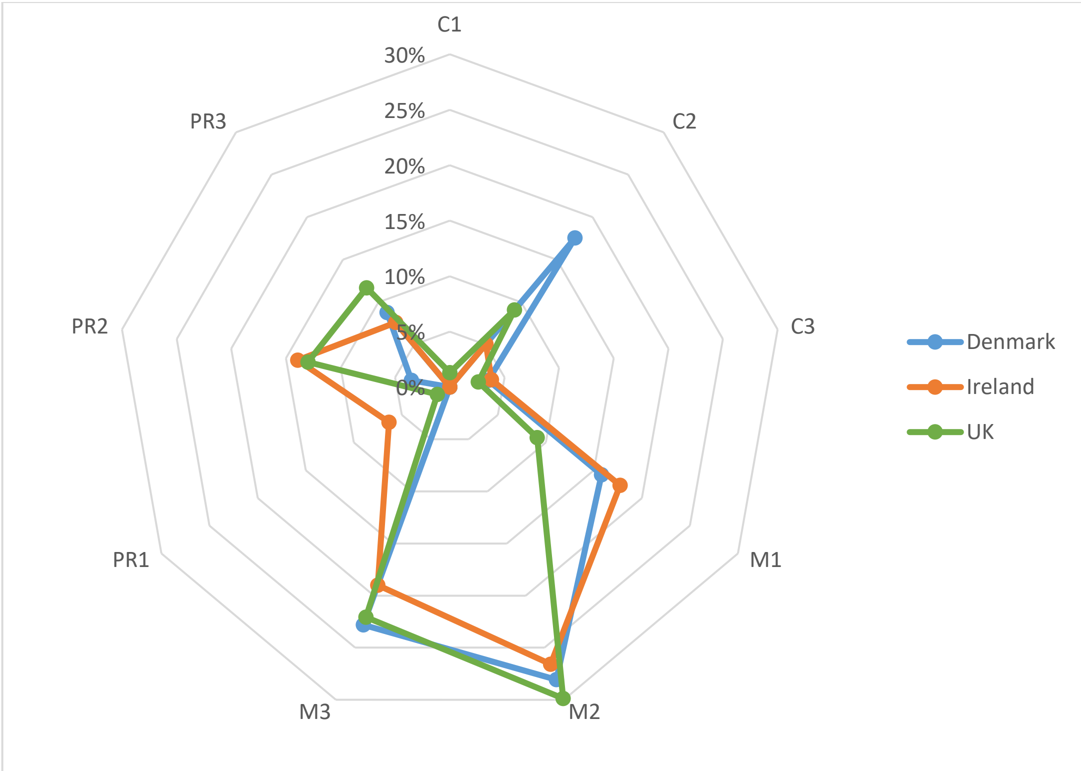

Figure 15 Representation of the focus in terms of scale and dimensions of social acceptance of RE in the NREAP policies of Denmark, Ireland and the UK

The distributions of codes associated with dimensions and scales of social acceptance within NREAP policies are represented in Figure 14, and more illustratively as web graphs in Figure 15. The results for Denmark, Ireland and the UK show a significant likeness. We observe:

- a prevalence of the market codes, in particular from the national to local scale (M2 and M3)
- a larger focus on community as energy producers (C2), compared to community at national and local individual levels (C1 and C3), which have very low mention rates
- medium mention rates for political-regulatory codes at the regional and local scale or among local authorities (PR2 and PR3)

	C1	C2	C3	M1	M2	M3	PR1	PR2
C2	1							
C3	1	4						
M1	0	4	0					
M2	0	9	1	22				
M3	0	11	2	6	25			
PR1	1	1	1	3	2	0		
PR2	0	1	1	4	12	2	3	
PR3	0	3	3	0	6	5	0	10

Figure 16 Heat-map representation of aggregated code co-occurrences within NREAP policies for Denmark, Ireland and the UK, highlighting interactions between two codes within a same policy

The representation of aggregated co-occurrences gives an overview of the dynamics that are predominantly enabled by NREAP policies. While results per country are detailed and discussed in sections 4.1 to 4.3 below, we can observe in this aggregated representation:

- a prevalent link between M2 and M3, suggesting that, globally, market-supporting policies are designed to include and potentially prioritise local companies. Intentional broad approach to market dynamics and opportunities
- a significant link between M codes and C2, which suggests an effort to include local energy producers and prosumers into financially supporting incentives otherwise aimed at elements of the market dimension

The selected approach of three case-study countries has been useful to explore policy dynamics in their national contexts. The findings are synthesised in a more holistic form adapted to the larger context of the EU arena and its role of overseeing decarbonisation targets. Thus, results from the framework analysis (Figure 10) are compiled and presented in Figure 17 as an illustrated summary of the interactions identified in each case study.

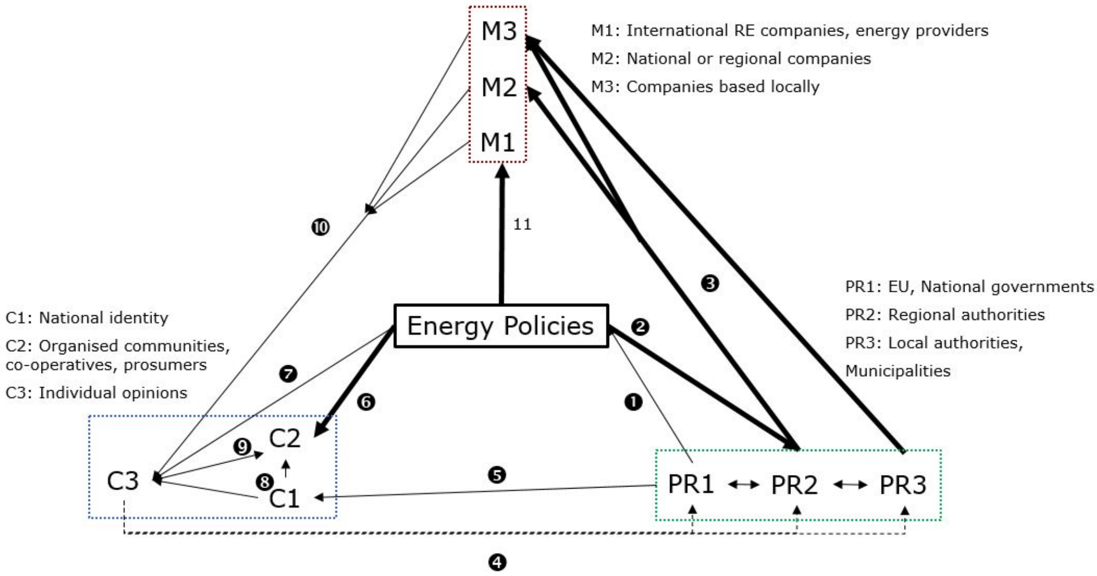

Figure 17 Analytical framework: representation of dimensions and scales of social acceptance with extended representation of dynamics between dimensions and scales – bold arrows represent interactions generally addressed by NREAP policies

1: PR1 to Policies: Government/energy agencies decide on a policy formulated following targets set by the EU

2: Policies to PR2–3: National policies instruct regional authorities on what to prioritise

3: PR2–3 to M2–3: Regional and local authorities collaborate with regional and local companies

4: C3 to PR1–3: Elections shape local to national socio-political systems; can object to planning project

5: PR1 to C1: Past/current energy systems; dissemination of information; government actions influence the national identity

6: Policies to C2: National energy policies orchestrate possibilities for cooperatives and local production

7: Policies to C3: Effects of PR1 through energy policies at the local community level

8: C1 to C2–3: National identity affects individual opinions

9: C3 to C2: Local support (or opposition) of local producers and cooperatives

10: M1–3 to C3: Impact of wind farms from local to international developers at local level C

11: Policies to M1–3: Policies set incentives and R&D priorities that affect energy companies from the local to international scales

Figure 17 highlights the finding that there are dynamics between the scales within each of the dimensions: Our analysis reveals that the scale aspect is an important consideration within energy policy formation in that different dimensions are emphasised in different scales. For example, the policies are more heavily influenced by market and policy regulation dimensions than by community considerations. When considering the community scale (and social acceptance), C2 is more heavily considered in policymaking in our sample countries – even in Ireland, where it is lower – whereas C1 and C3 are not; however, the C1 and C3 scales do have some influence on C2. The local scale is not necessarily difficult to target, but our analysis indicates that the policymaking process generally engages this scale through the market and political-regulatory dimensions.

For example, a change in acceptance at the C3 level can directly influence PR1, whereby a newly elected national government with a sceptical party line towards wind power can draw upon specific – even isolated – incidences of local (C3) opposition to inform and justify a change in 'national acceptance'. Indeed, this is what occurred in the UK following the election of the Conservative-led government in 2010. Similarly, in the case of Denmark, a change in national government in 2001 pushed an explicitly pro-market reform agenda. As such, they were not opposed to an expansion of wind power per se, only to the provision of subsidies to wind power, or indeed any subsidised technology. However, given the prevalence of community-owned wind farms, backed by FITs, this change in the PR1 had a material impact on the C2 and C3 levels of social acceptance.

In all three countries, the level of wind power planning (PR2) had a major influence on the social perception and acceptance of wind power at all community levels, given the rapid growth of proposal development and investment in the early 2000s. This growth led to various conflicts and controversies, which were only resolved – or even given a chance to be discussed – by the planning authorities (level PR2). While the planning authorities were themselves officially neutral on the issue of whether a specific project should be given approval – i.e., they operate against a rule-based set of criteria – their decisions (either for or against) influenced the wider social acceptance of wind (either for or against). These outcomes can be seen as an unintended consequence of the role and importance of planning authorities in approving specific projects.

Research into social acceptance of RETs has often concluded how dynamics occurring at the micro or local scale are being left out of top-down policy discussions and decision-making processes. This is shown to be partially true in our sample for the C and PR dimensions, but we observe a clear policy focus on the micro scale of the market sector, for which monetary incentives are easily calculated. This predominance of market criteria suggests that addressing the micro scale is not, per se, the issue for policymaking, rather it is the fact that the non-market aspects are inherently difficult to quantify and compare. Thus, considering the very limited focus on the micro scale of the community dimensions (C3), the challenge seems to be to propose policy tools adapted to dynamics that cannot be addressed solely financially or quantitatively. In short, the linear connection between techno-economic quantitative modelling and energy policies is the primary explanation for the high focus on market criteria, across scales.

3.6 Conclusion: Implications for future policies and the deployment of wind energy in Europe

This study builds from the recent development in the field of research on the social acceptance of renewable energy. The existing literature notes that social acceptance is achieved when a technology has secured market, socio-political and community acceptance. We show the importance of including scale considerations, as cross-scalar dynamics vary within each of the three dimensions, and as a consequence, dynamics between those dimensions cannot be studied as between homogeneously constituted elements. As such, we provide a comprehensive framework that addresses the need for a more exhaustive cross-scalar analysis of energy policies, especially considering the recent impacts of community acceptance and the difficulty that policies have in addressing it.

The broader point to emerge from the findings is that specific changes in any one or more of the nine components in the social acceptance framework can influence another – i.e., that there is a dynamic (non-linear) causal relationship between all aspects of the framework. From our analysis, it became clear that governments (including political and technical decision makers) in our three case study countries do not focus much on community aspects of social acceptance, it would appear that the broader definition of social acceptance, as defined in the literature, is not widely understood in these top-down forums. To a large extent, this reflects the influence of techno-economic models, which privilege the economic or 'market' criteria. Furthermore, full social acceptance is something that likely needs to be formally orchestrated given the dynamics we see between the nine spatial-dimensional components in our framework.

Chapter 4

STATISTICAL EVIDENCE ON THE ROLE OF ENERGY COOPERATIVES FOR THE ENERGY TRANSITION IN EUROPEAN COUNTRIES

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Abstract

The share of renewable energy is increasing throughout Europe. Yet, little is known about how much can be attributed to different actors, other than those commercially active. This paper provides empirical evidence of activities by energy cooperatives in the field of renewable energy in four different European countries. It draws from a database consisting of 2671 entries, contrasting results from current literature. We find that energy cooperatives are important enablers of the energy transition. However, their role is shrinking in recent years due to a tightening or removal of supportive schemes. We conclude that it is necessary to develop a systematic accounting system to properly track and make visible the contributions by different actors. In turn, this will help to better model the likely speed of Europe's energy transition.

4.1 Introduction

The transition to low carbon energy systems is on its way in Europe: Most countries are on track to achieving their specific 2020 targets and the share of renewable energy in final energy consumption at the European level has crossed 16% in 2014 (European Commission, 2018). However, there is a debate about how fast this process is going and to what extent it can be further accelerated (Fouquet, 2016; Grubler et al., 2016; Smil, 2016; Sovacool, 2016; Sovacool and Geels, 2016). There are two broad lines of approaching this issue, mainly under the labels of "techno-economic analysis" and the "socio-institutional analysis" (Sovacool and Geels, 2016). The former, with its emphasis on the difficulty of changing existing energy infrastructures and connected established markets, generally points to longer transition times. Whereas the latter tends to be more optimistic, highlighting opportunities for a broad range of societal actors to be innovative curbing the energy transition beyond historically observed rates of transition. Techno-economic analysis is better quantifiable with the help of energy system models, while socio-institutional analysis poses difficulties for estimating at the aggregated level. The reason for this is due to the case studies that dominate in this field of research and implications aiming at the aggregate level stay qualitative.

This is the starting point for our quantitative investigation in which we focus on the role of the actor "energy cooperatives" in Europe to support the energy transition. Energy cooperatives are innovative social structures that find collective solutions to problems occurring during transition processes or provide testbeds for adapting low carbon energy technologies to local conditions and needs (Bauwens et al., 2016; Holstenkamp and Radtke, 2018; Huybrechts and Mertens, 2014; Tarhan, 2015). Various forms of energy cooperatives exist and the energy services they provide are broad, ranging from electricity provision to district heating, IT solutions and energy efficiency consulting. Their organizational structures differ across Europe due to country-specific regulatory frameworks and local needs. However, there are common denominators which clearly distinguish them from established commercial actors in energy markets, such as energy utilities. Common characteristics include the involvement of the wider public (enabling the direct participation and ownership of members), the pursuit of non-commercial benefits (such as the fostering of community spirit) and the motivation to accelerate the transition to sustainable energy systems (e.g., phasing out nuclear power, regaining local ownership and control of energy provision). The role of energy cooperatives in contributing and steering the energy transition is thereby important beyond the expansion of installed capacities, in particular through building acceptance for the necessary changes and through the finding and implementation of creative solutions that benefit the development of local communities. However, the contribution of energy cooperatives to the European energy transition has not yet been estimated at the aggregate level. This paper is the first attempt towards such an estimate. We focus on empirical evidence in selected European countries guided by two main questions:

1. Is there statistical evidence that energy cooperatives are important actors in the energy transition in Europe?

2. What are common reasons that support or hinder activities of energy cooperatives?

This paper aims to answer the above questions using statistical analysis and drawing from evidence provided in various literature. Doing this, we aim to fuel the discussion about developing a systematic accounting for actors of the energy transition beyond those commercially active (see for example (Viardot, 2013) on differences between these two general types of actors). Our database of energy cooperatives comprises entries from Austria, Germany, Denmark, and the United Kingdom, totalling 2671 entries. We combine the statistical analysis with the review of case studies. It allows us to draw conclusions at the European and individual country levels on how to support energy cooperatives. To the best of our knowledge, we offer the most comprehensive statistical analysis on energy cooperatives in different European countries to date.

The paper is organized as follows. The next section reviews available literature on cross-country studies of energy cooperatives. Section 4.3 describes the methodology for building the statistical database. Section 4.4 presents results for cross-country statistics followed by the presentation of results from the analysis of individual countries. The results will be contrasted with other evidence found in the literature. Section 4.5 combines all results together to draw conclusions.

4.2 Literature review

Community activities in energy production and their relevance for the sustainable energy transition have attracted increasing attention in research during the last two decades with a vast body of literature available. However, most of it focuses on single countries or case studies. In this study we specifically focus on organizational structures that can be labeled as “energy cooperatives” (refer to country-specific definitions in the Methods section). Recommended entry points to the literature are (Becker et al., 2017; Brummer, 2018; Debor, 2018; Holstenkamp and Radtke, 2018). Recent country-specific entry points to the literature are: Germany (Debor, 2018; Holstenkamp and Radtke, 2018), Denmark (Hvelplund et al., 2017; Mey and Diesendorf, 2018), Belgium (Bauwens and Defourny, 2017), Sweden (Bohnerth, 2015; Kooij et al., 2018), UK (Berka and Creamer, 2018), Finland (Korjonen-Kuusipuro et al., 2017), Spain (Heras-Saizarbitoria et al., n.d.), Italy (Magnani and Osti, 2016), Austria (Schreuer, 2016)(Schreuer, 2018), France (Mignon and Rüdinger, 2016), Netherlands (Oteman et al., 2017).

Only 11 publications go beyond the study of single countries (Bauwens et al., 2016; Becker et al., 2017; Bohnerth, 2015; Brummer, 2018; Curtin et al., 2018; Dóci and Gotchev, 2016; Hoicka and MacArthur, 2018; Kooij et al., 2018; Mignon and Rüdinger, 2016; Oteman et al., 2014; Viardot, 2013). Denmark and Germany are the countries most often cited in these comparisons, coinciding with the fact that Denmark has been a pioneer country in the development of energy cooperatives since the 1970s, while Germany saw a boom in the foundation of energy cooperatives in the aftermath of the Fukushima disaster in 2011. Great Britain and the Netherlands are also focal countries. While energy cooperatives differ in size, strategies and success, the cross-country comparisons clearly document that there are common features among energy cooperatives in Europe. All publications stress the important role of community activities in the transition towards sustainable energy systems. An early example from the literature is (Viardot, 2013) who looks at energy cooperatives in Denmark, Canada, the United Kingdom, and Germany. The author emphasizes the collective actions contributing to lowering the costs of renewable energy and to act as multipliers of renewable energy solutions. (Brummer, 2018) identifies in addition the benefit of local community development in a study for Germany, United Kingdom and the USA.

However, energy cooperatives continue to rely on governmental support to play a role in liberal markets and against incumbents (Bauwens et al., 2016; Brummer, 2018; Kooij et al., 2018; Oteman et al., 2017). Many studies also agree in the identification of common barriers. This includes the lack of knowledge and financial infrastructures as well as a hostile institutional context (Mignon and Rüdinger, 2016). Notably, a variety of solutions were found to overcome these barriers and that helped to feed a pool of best practices relevant across countries. However, community initiatives are less likely to be successful if their rationale for action is at odds with the government (Oteman et al., 2014). A qualitative study (Bauwens et al., 2016) on energy cooperatives confirmed the relevance of support instruments for renewables, planning policies, attitudes towards the cooperative model as well as local energy activism on the success and failure of energy cooperatives in Denmark, Germany, Belgium and the United Kingdom. The authors of that study emphasize that energy cooperatives are recently experiencing increased pressure due to changing policies and higher competition in local energy markets. In addition to adapting their activities, energy cooperatives are beginning to react to these challenges by establishing cooperation among single entities (see also (Becker et al., 2017) on “communities of interest“. The authors study community activities in the United Kingdom, Italy, Spain, and Germany.). In addition to the fact that such new networking activities are a response to challenges, it underlines the transformative potential that energy cooperatives possess beyond the local level. (Curtin et al., 2018; Dóci and Gotchev, 2016) focus on the role of financial incentives and associated risks. The common finding is that regulatory uncertainty and decreasing financial support strongly undermines the foundation of new and the continued success of existing energy cooperatives.

Finally, an interesting common aspect is put forward in (Hoicka and MacArthur, 2018). The authors analyze the influence of historical conditions on the founding of energy cooperatives in Canada and New Zealand. One key element is that many actors seem to belong to groups outside of the main stream (e.g., ethnic minorities). Often the founding of cooperatives by these groups coincides with a lack of awareness by the political establishment in these countries. Similar parallels can be drawn to European countries in that pioneers of energy cooperatives are also often built by societal groups that aim to demonstrate alternatives to established socio-political structures (e.g., anti-nuclear movement in Germany).

4.3 Methods

Our statistical analysis focuses on Germany, Denmark, the United Kingdom and Austria. Besides Austria, all countries are focal countries in the qualitative studies described in Section 4.2. These countries also have the largest numbers of energy cooperatives in Europe (Bauwens et al., 2016), justifying a statistical analysis of these actors. Moreover, these countries provide access to standardized sources of data about energy cooperatives. Good data coverage is also the rationale to include Austria. For each country, we selected those specific legal forms, which come closest to the concept of an energy cooperative (see specific definitions below). It is important to stress that we are far from providing a comprehensive accounting for energy cooperatives in the European Union. However, capturing focal countries and well-known regulatory frameworks in each of them, we are able to provide a profound lower estimate for the aggregate contribution of energy cooperatives in Europe.

We generated a multi-country database of energy cooperatives which contains 282 entries for Austria, 1109 entries for Denmark, 965 entries for Germany, and 315 entries for the United Kingdom. The database has been constructed from accessing national official registries of energy cooperatives that typically detail the date of foundation (and cancellation), their addresses and sources for further information. We searched for registered cooperatives active in the field of renewable energy to build an initial list (Compass Verlag GmbH, 2018; Firmen ABC Marketing GmbH, 2018; Handelsregister.de, 2018; HEROLD Business Data GmbH, 2018). We extended entries for further information on member statistics, finances, and the evolution of cooperatives.

Table 11 provides methodological details for each of the countries and sources of information. In addition to the main registries shown, we also collected information on single cooperatives from self-profiling websites, discussion forums, newspaper articles etc. In cases of deleted energy cooperatives, we further accessed archived webpages available from archive.org. Since the availability of open data on cooperatives varies from country to country due to legislative differences and the amount of voluntary information provided by cooperatives, it was not possible to obtain the same level of detail for all countries and all entries. However, we have a complete set of data for all countries for the date of foundation, cancellation and location of each cooperative. Furthermore, for each country, the basic data set could be extended further, which led to our choice of analysis foci for each country. Firstly, for Denmark we were able to collect detailed data on membership (including type and residence of members), secondly, for Germany the field of activities, evolution of membership and financial shares and, thirdly, for United Kingdom the evolution of financial resources. For the sake of a concise paper, we only briefly cover Austria.

In order to ensure high quality data, we have verified the statistical information on single cooperatives with different sources of information wherever possible. For example, regarding cooperatives from the United Kingdom the list of societies has been compared with a recent review by coops.uk (The Co-operative Economy, 2018). For the final creation of database entries, we further applied the four-eyes principle checking for typos, duplicate data and completeness of entries.

Definition of Cooperative	Main Sources of Information	Search Terms	Information Collected
Austria (282)—Focus on Case Studies (Default)			
eingetragene Genossenschaft	Compass Verlag Gmbh (firmeninfo.at), Firmen ABC Marketing GmbH (firmenabc.at), HEROLD Business Data GmbH (herold.at)	Wärmeversorgung, Elektrizität, Kraftwerk, Solar, Sonne, PV, Photovoltaik, Energie, Windkraft, Wasserkraft	addresses, dates of incorporation/cancellation, type of activities
Denmark (1109)—Default Focus, Statistical Focus on Membership			
Interessentskap	Central Business Register (datacvr.virk.dk), Danish Energy Agency (ens.dk)	vindmøllelaug, møllelaug	addresses, dates of foundation/cancellation, type of activity, geographic information on members (incl. type and residence of member), local production capacities from wind
Germany (965) —Default Focus, Statistical Focus on Activities and Membership Dynamics			
Genossenschaft	Trade Registry (handelsregister.de), Business Registry (unternehmensregister.de)	Energie, Bürgerenergie, Energiegenossenschaft, Wasserkraft, Windkraft, Elektrizitätsversorgung, Energieversorgung, Strom, Solarstrom, Sonnenstrom, Kraftwerk, Windenergie, Windpark, Solarpark, PV, Photovoltaik, Wasserkraft	addresses, dates of foundation/cancellation, evolution of shares and membership, type of activities, production capacities (partly)
United Kingdom (315)—Default Focus, Statistical Focus on Finances			
BenCom (registered under the Co-operative and Community Benefit Societies Act 2014)	Financial Conduct Authority (fca.org.uk), Companies House (beta.companieshouse.gov.uk)	energy, solar, wind, wood, heat and hydro	date of foundation (cancellation), address, number of members and amounts raised (incomplete), production capacities (incomplete)

Table 11 Energy cooperatives included in the database: Overview on methods of search, sources and information collected

4.4 Results and Discussion

4.4.1 Cross-Country Results

Building on the compiled database as described in the previous section, Figure 18 shows the development of the number of active energy cooperatives in the last four decades for Austria (AUT), Germany (DEU), Denmark (DNK) and Great Britain (GBR). Although our data for Denmark only includes wind energy related cooperatives, the country has very clearly been the pioneer in establishing energy cooperatives in early years and also in absolute numbers. This is remarkable in view of population numbers: AUT—8.4 million, DEU—81.8 million, DNK—5.5 million, and GBR—62.0 million (all are given for 2010).

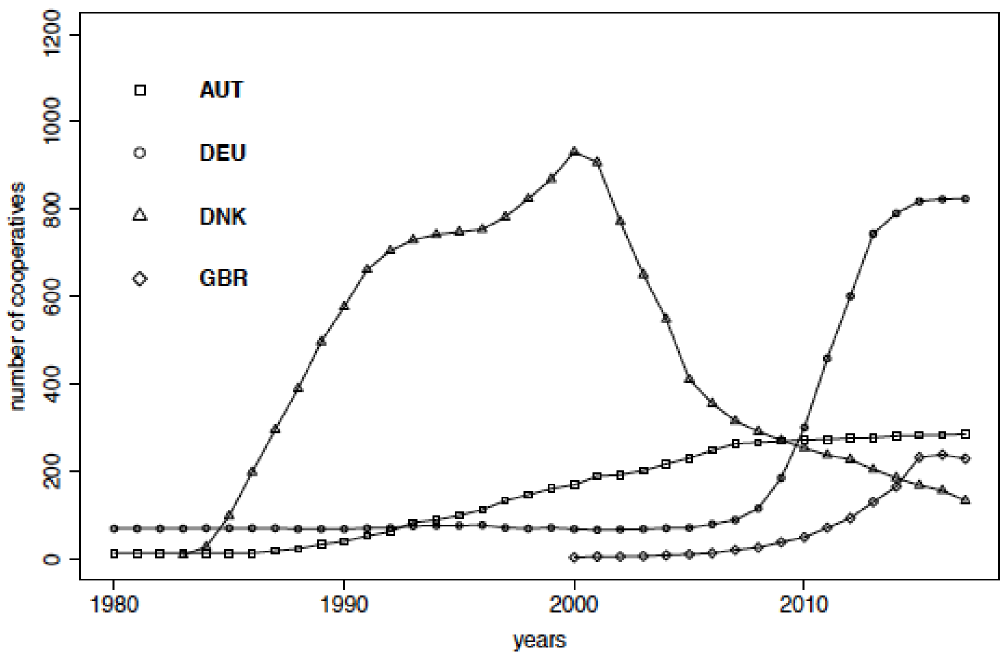

Figure 18 Number of energy cooperatives in Austria (AUT), Germany (DEU), Denmark (DNK) and Great Britain (GBR) for a given year. Source: database compiled by authors, for original sources see Table 11 and methods section

However, a stark decline in the number of Danish energy cooperatives can be observed from around 2000 onward. As of June 2018, Germany has the largest number of active energy cooperatives with 824, reaching numbers close to Denmark's former peak in 1999 which was at 931. While the increase in Germany has only taken speed over the past decade, the number of active energy cooperatives is on a slow increase in Austria since the late 1980's and Great Britain since the late 2010. The latest numbers for both are 286 and 230, respectively.

Figure 18 can be compared with a snapshot for 2014 derived from a database owned by the European Federation of Renewable Energy Cooperatives (REScoop.eu), refer to (Bauwens et al., 2016). The network is a sector association of Cooperatives Europe and has currently about 1500 members from the European Union. The 2014 snapshot of the number of cooperatives active in REScoop counts for around 800 energy cooperatives in Germany (in this paper: 791), 650 in Denmark (here: 186), just below 400 in Austria (here: 282), slightly above 100 in Netherlands and Sweden, about 80–90 in Finland and Italy, less than 70 in France and Great Britain (here GBR: 166), between 10–20 in Spain and Belgium, and not more than 5 in Ireland, Portugal, Croatia, Greece and Luxembourg. Germany, Denmark, Austria and Great Britain alone account for about 80% of the total energy cooperatives in the entire European Union. Differences between the numbers from REScoop and our compilation stem from our focus on specific cooperatives (see definitions in the previous section). For example, we only account for wind energy related cooperatives for Denmark, disregarding cooperatives active in district heating or solar. However, in the case of Germany, we came close to the number of REScoop entries. Also tracking cooperatives that have been terminated, we know that those terminated are exceptionally high in Denmark, while rates are more modest in Germany. This may suggest that REScoop did not remove terminated energy cooperatives from its compilation. Furthermore, since the REScoop database is not publicly available, differences cannot be fully clarified. On the other hand, considering the development shown in Figure 18, the focus on just four countries for the analysis in this paper is a good representative share of energy cooperatives active in Europe.

Figure 19 presents the share of renewables in total final energy consumption for the four different countries between 1990–2015. Clearly, the shares have been steadily increasing from very low numbers in the 1990's (below 10%) for all countries except for Austria (25%), where hydro power traditionally plays an important role. The fastest increase can be reported for Denmark, echoing the early activities of energy cooperatives in the small country. The lowest share number of energy cooperatives was reported in the United Kingdom, with initiatives under 10% in 2015. Again, this mimics the low numbers in energy cooperatives. The following is an in-depth discussion to better understand energy cooperative developments in several individual European countries.

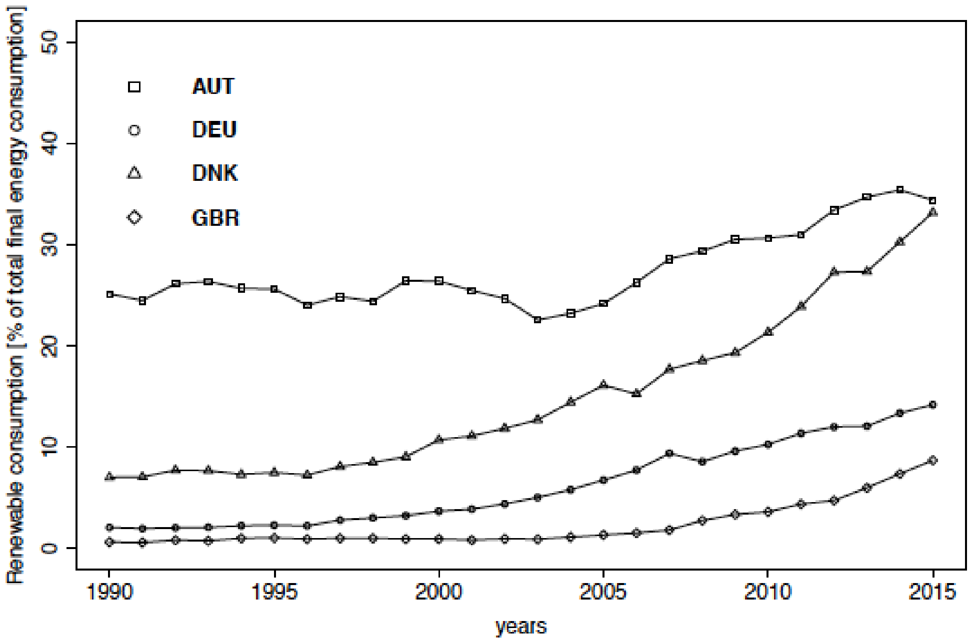

Figure 19 Renewable energy consumption as percentage of total final energy consumption in Austria (AUT), Germany (DEU), Denmark (DNK) and Great Britain (GBR) for a given year. Source: The World Bank Data Bank 2018

4.4.2 Denmark

Prior to the 1970s oil crisis, Denmark was reliant on imported petroleum for nearly 80% of its energy needs. After the embargo, Denmark began to shift away from fossil fuels in order to promote energy security (Rüdiger, 2014). Collective anti-nuclear networks formed the basis for cooperatives (Mey and Diesendorf, 2018). Geographically, Denmark has abundant wind resources, and wind cooperatives were successful in bringing the costs of turbines down and generating public acceptance of renewable energy. By 2017, 49% of the electricity produced in Denmark originated from wind-based energy; 6214 turbines were in operation as of April 2018 (see also Figure 20 for the development of installed capacities based on data from the Danish Energy Agency (Danish Energy Agency, 2018)). In 2002, energy cooperatives owned about 40% of the then installed turbines, revealing that energy cooperative initiatives were important for the Danish energy transition (Krohn, 2002). Moreover, 150,000 households participated in wind power cooperatives underlining the great support from the broader society (ibid.).

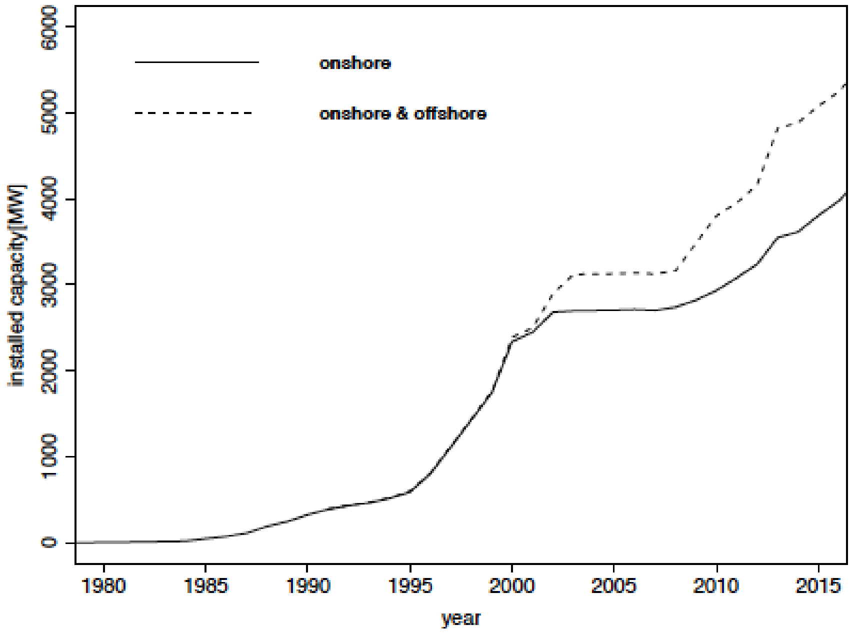

Figure 20 Installed capacity of onshore and offshore wind farms in Denmark. Source of data:(Danish Energy Agency, 2018)

By the 1990s, there was a diminishing role for the collective ownership model, shifting toward more private ownership, typically by farmers (Hvelplund, 2006). This was supported by a 1992 feed-in tariff program for wind, and guaranteed interconnection and power purchase at a "fair price" at 85% of retail rates (Farrell, 2009). Additionally, wind projects were eligible for a refund from the Danish carbon tax and a refund on the energy tax, essentially doubling the payment for wind power (Bolinger, 2001). In 1999, the Danish parliament ratified the Energy Supply Act, which among other measures, gave customers the freedom to choose their electricity provider and promoted a quota system for renewable energy through certificates. This required consumers to purchase a certain share of renewable energy in order to further establish the market (Ocana et al., 1999).

However, in 2002, the newly elected centre-right Danish parliament announced the end of feed-in tariffs for wind energy. They argued that wind was mature enough as a technology to not warrant further government support and pushed for market liberalization as an attempt to increase competition and lower consumers' electricity costs. The tariff was phased out in 2004, resulting in a substantial decrease in wind energy cooperatives. This suggests that the technology had reached a level of maturity that economies of scale were achieved. This made it economical for larger companies, such as energy service providers, to enter the market. However, this was not the case for existing cooperatives, which owned a smaller number of turbines. These developments coincided with technological improvements and legislative changes that favored larger wind park installations. The size of turbines grew from 55 kW to 3.3 MW and beyond, and their height doubled. Furthermore, the typical investment size changed from 0.5–0.8 million euro to about 15–22 million euro (Moné et al., 2014). These developments marked the start for the sharp turn in support for wind cooperatives in Denmark. This is clearly mirrored in the data.

Our database contains 1109 registered wind energy cooperatives in Denmark (i.e., all wind power-related 'interessentskap' registered under the Danish law). In addition to the development of the number of cooperatives in the last four decades already shown in Figure 18, Figure 21 adds information contrasting the date of foundation with the dates of termination for Danish wind cooperatives. From both figures, it is evident that two waves of foundation can be observed: The first appearing between 1985 and 1992 and the second between 1998–2002. Afterwards, the majority of energy cooperatives were terminated at an exponential rate. The developments correlate strongly with political decisions made since 2002 which were likely anticipated before enacted. Furthermore, 2003 marked the beginning of the era of commercial offshore wind park investments (refer to Figure 20). Cooperatives that were driving onshore wind developments, were not able to enter the offshore wind markets at the same time.

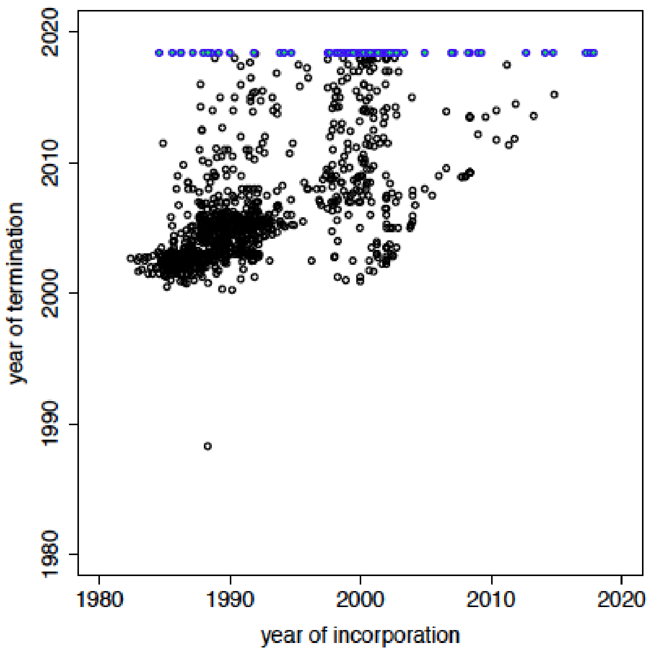

Figure 21 Timing of wind cooperatives in Denmark shown by contrasting the date of foundation with termination dates. Wind energy cooperatives which are still in operation are marked blue, the date of termination is set equal to June 2018. Source of data: own database building on (Virkdata, 2018)

Today, only 12% out of the 1109 cooperatives still exist and data indicates a continuation of this trend. Our data are in line with the observation by the Danish Wind Turbine Owners Association, reporting that in 2010 only 15% of all turbines in Denmark were still owned by cooperatives (Skotte, 2010). While many turbines had reached their end of life, others were also sold to utilities

(Mey and Diesendorf, 2018). These firms are also investing in land, often discreetly, and have the advantage of large legal teams to secure their interests (Olesen et al., 2004). Technologically, it is hard to argue against: large-scale developers are efficient businesses that do a lot investment in land with high wind potential, and the cooperatives have a difficult time competing with these. Obviously cooperatives—the early pioneers of wind development in Denmark—had lost ground. The Danish parliament took note of this development and tried to stimulate local ownership. In 2009, the Danish Renewable Energy Act (DEA) introduced the Option to Purchase wind farm Shares Scheme (OPSS) which stipulated that 20% of the shares of a new wind project must be available for sale to residents within a 4.5 km radius of a new wind project (Promotion of New Energy Act, 2009). While a survey-based study has suggested that this has had a positive impact on co-ownership, it has not solved everything in terms of acceptance since it is only aimed at people with sufficient liquidity of funds (Johansen and Emborg, 2018). Likewise, support for the scheme is largely dependent on demographic variables (ibid). We do not find any response from the OPSS in the data.

We can shed new light into what happened by analyzing the development of membership numbers (i.e., the number of fully liable participants) and the distribution of addresses. Figure 5 shows the percentage of cooperatives sorted into 5 different size classes, with the smallest having only up to 5 members and the largest more than 200. Data for the whole sample of cooperatives are shown as well as the sub-sample of those still existing. In both, small cooperatives dominate. However it is especially the medium-sized cooperatives that disappear. Figure 23 investigates this further by analyzing the percentage of existing cooperatives in different size classes. The majority of the largest cooperatives survived, since only 4 out of 9 have been closed down. However, the smallest size class with up to 5 members and the second-largest size class with 51–200 members lost as much as 85%, even surpassed by the medium size classes with 5–50 members, losing more than 92% of the cooperatives. This suggests that smaller- and medium-sized energy cooperatives were unable to survive the trends towards larger projects and higher market competition (coinciding with less governmental support) by discontinuing their engagement in the wind energy market.

Figure 24 shows the geographic distribution of energy cooperatives founded in a particular municipality since 1980. Associated shares of the full sample are indicated by different colors. Thisted, a municipality located at the Western coast of Jutland, is the most active municipality in hosting wind cooperatives, with 8% of the country's share. Overall, most cooperatives were founded in the northwest, while the distribution is rather equal in the rest of the country. The picture is very different today, as can be inferred from Figure 24. The blue diamonds mark the existing wind cooperatives across the 98 Danish municipalities as of June 2018. Those still existing cluster around the northwest, the island Funen and along the border with Germany. Most of the former cooperatives from Falster, Lolland and Zealand disappeared.

The findings from Figure 24 are connected with the decisions on where to place wind turbines. In the 1980s and early 1990s, turbines were placed throughout the landscape and not necessarily in the areas with greatest wind potential. This resulted in a situation where the turbines had a large visual impact on the landscape, with many smaller turbines in sub-optimal locations from the perspective of the national wind potential (Danish Energy Agency, 2015). To counteract this development, wind planning zones where established in 1995 (Danish Energy Agency, 2015; Möller, 2010; Sperling et al., 2010). Also, in 2001 the scrapping schemes were designed to rectify the situation, and municipalities were tasked with planning the siting of wind turbines. They took advantage of the areas with the greatest resource potential while at same time taking into account residential, environmental, cultural, and landscape considerations (Danish Energy Agency, 2015). Concurrently, Denmark reduced the number of turbines in two waves. During the period from 2001–2004 the numbers went down by 1208, while at the same time, increasing wind power capacity by 202 MW (Sperling et al., 2010). In the period from 2004–2011, subsidy schemes were installed to incentivize owners of turbines to replace smaller ones (25 kW for domestic turbines, 450 kW for grid connected turbines), for up to 175 MW pooled capacity (Danish Ministry for Energy Utilities and Climate, 2010). Eventually, municipalities tended to favor fewer and larger turbines. Consequently, wind cooperatives disappeared in areas with low wind yields concentrating in others, which is in agreement with data shown in Figure 24. Notably, Thisted is located in the region with the highest wind yields in Denmark.

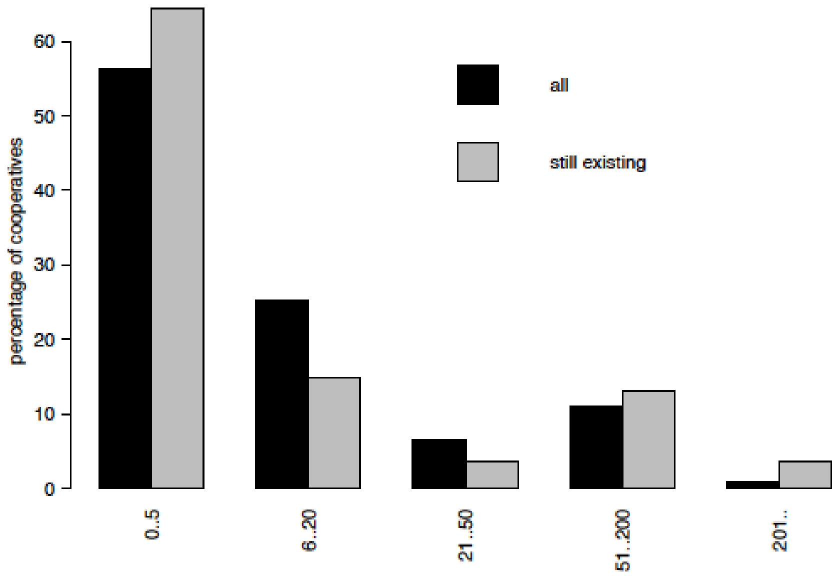

Figure 22 Membership size of wind energy cooperatives in Denmark in five different size classes. Source of data: own database building on (Virkdata, 2018)

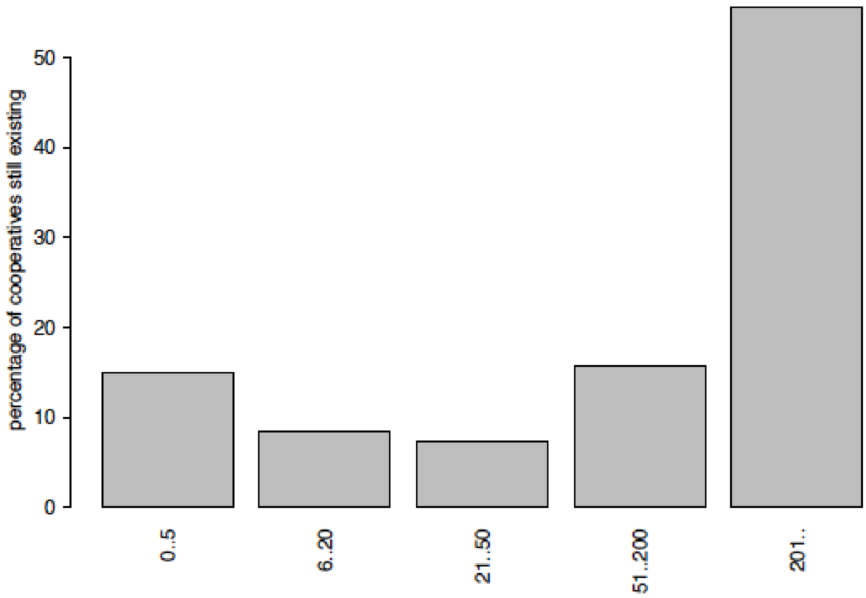

Figure 23 Percentage of cooperatives still in operation in five different size classes. Source of data: own database building on (Virkdata, 2018)

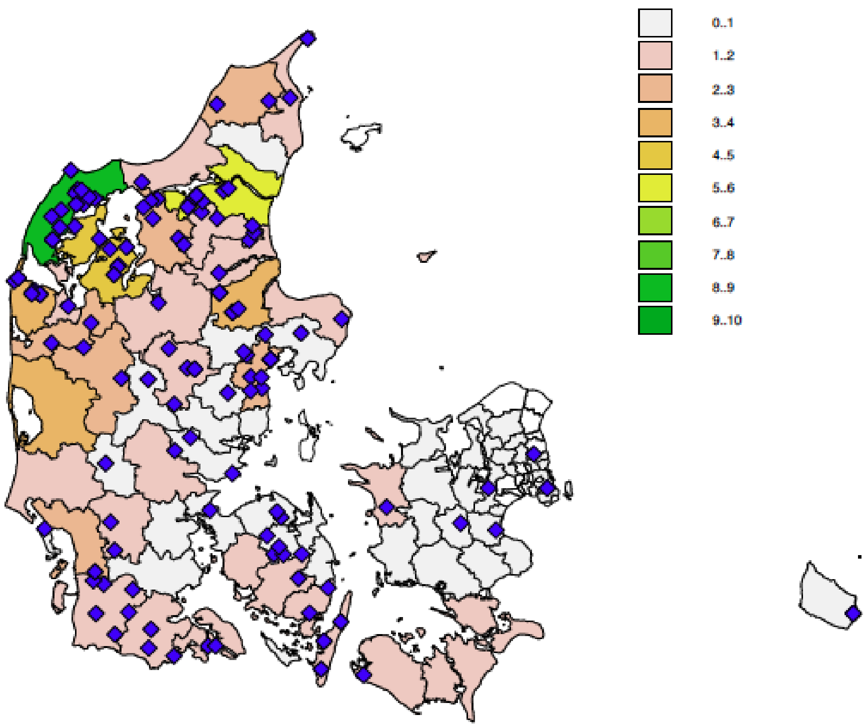

Figure 24 Geographical distribution of existing wind cooperatives (blue diamonds) across the 98 Danish municipalities since 1980. The colour coding marks the percentage of energy cooperatives in the full sample (incl. terminated ones) that are associated with a specific municipality. Source of data: own database building on (Virkdata, 2018)

The role of the early pioneers of the Danish energy transition is likely to become further marginal. Beginning in 2019, onshore will be ruled by tendering processes for all sizes of wind farms, which means that cooperatives will be placed at an even greater disadvantage against large-scale developers. Developers are buying houses to clear out more available land, expecting a return on investment, so they are expected to be quite competitive in the tendering process. In interviews, cooperative leaders expressed concern for what this means for the cooperatives on their respective islands, e.g., Samsø and Ærø (personal communication from the authors). To date, these cooperatives have largely been referred to as success stories in providing sustainable energy while generating income to the islands' residents. Few efforts exist to sustain the wind cooperatives in Denmark by providing legal and financial information.

Finally, in the 2018 energy agreement, the Danish government outlines a strategy to further reduce the impact on the landscape and more than halve the number of onshore turbines by 2030, from 4300 to 1850. Furthermore, the provision of new turbines will be dependent on the number of turbines removed. Direct support for household turbines is also discontinued after 2020. This is a clear move away from the cooperative model for wind energy in Denmark.

However, recent research argues that these incentive schemes are at odds with a sustained provision of electricity in a 'high wind future'. Hvelplund et al. (2017) (Hvelplund et al., 2017) expect that the continued decrease of wind power prices at the spot markets will prevent profitability of wind farms in Denmark. The authors suggest as a countermeasure to push investments into advanced infrastructure, also integrating of the transport sector with wind-to-fuel technologies. Furthermore, local acceptance (Anshelm and Simon, 2016; Johansen and Emborg, 2018) is key for achieving the necessary changes. Here, new opportunities for cooperatives may open up to influence the transition once again.

4.4.3 Germany

Our database encompasses 965 energy cooperatives for Germany, most of which have been established since 2010 (see Figure 18). This development is to a large extent a reaction to the Fukushima Daiichi nuclear disaster in 2011 which led to the decision to phase out nuclear power in Germany by 2022. At the same time it was decided to accelerate the low carbon energy transition, known as "Energiewende". The Renewable Energy Resources Act, which was enacted in the year 2000, has been the key policy, granting fixed feed-in tariffs and priority feed-in for electricity that originates from renewables. This enabled other support mechanisms such as loans and grants at better conditions, leading to the notable growth of energy cooperatives and other forms of citizen-led energy initiatives (Bauwens et al., 2016; Klagge and Meister, 2018; Müller and Holstenkamp, 2015; Viardot, 2013; Yildiz et al., 2015). All of these initiatives contributed 47% of renewable energy capacities installed by 2012; the share of energy cooperatives was 9% (trend:research and Leuphana, 2013).

Cooperatives, including energy cooperatives, have a long tradition in Germany. Most of the 8100 cooperatives with 21 million members are engaged in the banking and trade sector. It was largely energy cooperatives that were driving the electrification of rural areas in the beginning of the 20^{th} century (Holstenkamp, 2015). Our database contains 72 energy cooperatives that were founded before 1950. 70% of those established during the 1920s (i.e., 27) are still existing today. Cooperatives are organized in the German Cooperative and Raiffeisen Confederation (Deutscher Genossenschafts- und Raiffeisenverband e.V., short: DGRV). This confederation also conducts yearly surveys among its members and publishes reviews and data.

We start by comparing our base data with those published in the most recent survey (DGRV, 2018). As of 2016, we have information about memberships for 601 cooperatives. As much as 197,686 persons are organized in these cooperatives, corresponding to a number claimed by the DGRV which reports 165,000 persons in 2015 (ibid.). The lower number is likely caused by the statistical error due to the low response rate of only 34% in the DGRV survey. Our mean number of members equals 329, which again is higher than 221 as reported by DGRV. The number of total shares invested in the cooperatives amounts to 596,383,202 euro, a number which is based on information available from 566 out of the 965 registered energy cooperatives. In comparison, DGRV reported 655 million euro in total capital invested by members, a number comparable to our data.

While the number of energy cooperatives in Germany are similar to Danish cooperatives during the 2000s (see Figure 18), the fields of activities are much broader. 360 (60%) are active in solar PV, 186 (31%) in heat and wood-based renewable energy, 120 (20%) in onshore wind energy, 90 (15%) in energy trade, 52 (9%) in biogas, 22 (4%) in hydro power, and 46 (8%) engage in consulting. Note that numbers can be higher than 100% because multiple activities are possible. New fields of activities include the provision of broadband internet access, e-mobility and car sharing. However, the numbers in these new fields are still small. 31 of Germany's energy cooperatives possess their own electricity distribution network. Total numbers of installed capacities are often not available since this information is not required to be reported officially. However, an estimate from 2012 amounts to 6.7 GWh (trend:research and Leuphana, 2013).

Although the data underscores the importance of energy cooperatives for Germany's energy transition, the number of newly founded energy cooperatives has declined recently. Klagge and Meister (Klagge and Meister, 2018) refer to it as the "end of the boom". Our data also confirms this decline in newly founded cooperatives (see the blue markers in Figure 25). However, the observed backward trend in the number of newly founded cooperatives does not necessarily signify a decline in engagement. For many cooperatives in our database, the number of members in existing cooperatives is indeed continuing to increase, albeit the overall slowdown in growth. The red markers in Figure 25 show these rates of membership increase per year for a subsample of 300 cooperatives. The gain in membership peaked in 2013, along with a peak in the growth in assets held by energy cooperatives. The data show that the decline in the growth rates is stronger for the number of cooperatives and less pronounced for membership and assets.

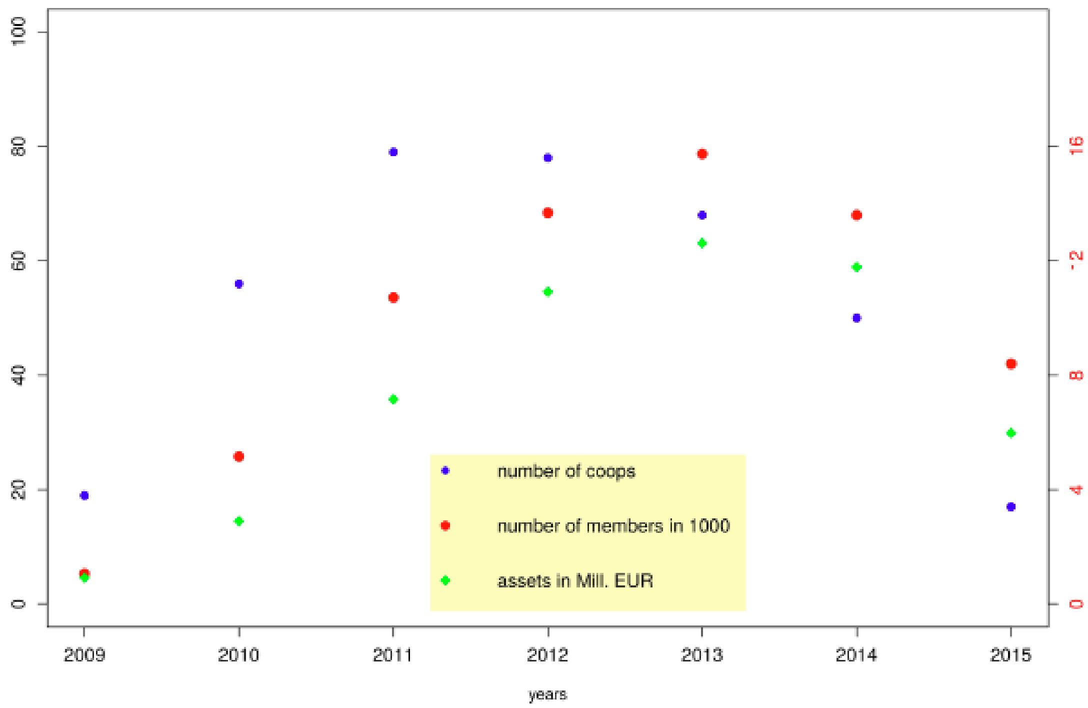

Figure 25 Increase in number of newly founded cooperatives (blue marker) and invested shares (green)—see the axis to the left—and new members (red)—see the axis to the right. Source: own database building on (Bundesanzeiger Verlag, 2018; Handelsregister.de, 2018)

The backward trends strongly coincide with revisions in the Renewable Energy Resources Act in 2012, 2014 and 2017. A central reason for the revision was related to the stability of the electricity grid despite the high penetration rates of fluctuating renewable energies along with rising electricity prices. This led to the introduction of a cap for the prioritized feed-in tariff (FiT) from renewable sources from 2012 onwards. In addition, the FiT schemes were revised in 2014. The latter was discussed as one of the main reasons for the termination of activities (DGRV, 2018; Klagge and Meister, 2018). The FiT was gradually replaced by a tendering system for most of the renewables, a development also seen in Denmark. As of 2015, the auctioning system was enacted and established 3–4 bidding rounds for solar PV and wind each year. In order to support citizen-led initiatives, small-scale installation are exempted.

Our database also provides an overview of membership dynamics. Figure 26 shows the evolution of memberships for 495 out of 965 energy cooperatives (normalized to the year 2016). Different types of dynamic patterns can be distinguished. These are indicated by different colors. Red is the group of cooperatives that increase most rapidly in membership, followed by green, blue, and gray. Those indicated in black hardly change in the number of members over the years. As expected, older cooperatives tend to be more stable in size. While most of the cooperatives show a continued increase, few of them declined recently. To investigate whether there is a correlation between the dynamic patterns and the size of the cooperative, Figure 27 plots the average rate of increase in membership size versus the size of the cooperative in 2016. As seen from the figure, the growth in membership is rather independent from the size of a cooperative. Figure 28 shows the relationship between the change in number of members from 2015 to 2016 against the change in the number of shares during the same period. Additionally, the size of the energy cooperative is indicated by the color coding, ranging from light colors signaling small cooperatives to dark blue signaling large cooperatives with 500 members or more. Most of the data are located in the first quadrant indicating a growth in both dimensions. Also note that some of them are growing more than proportionally (see the area in the upper left corner). There is no example found in the lower left area, because new members always have to sign a minimum share in a cooperative.

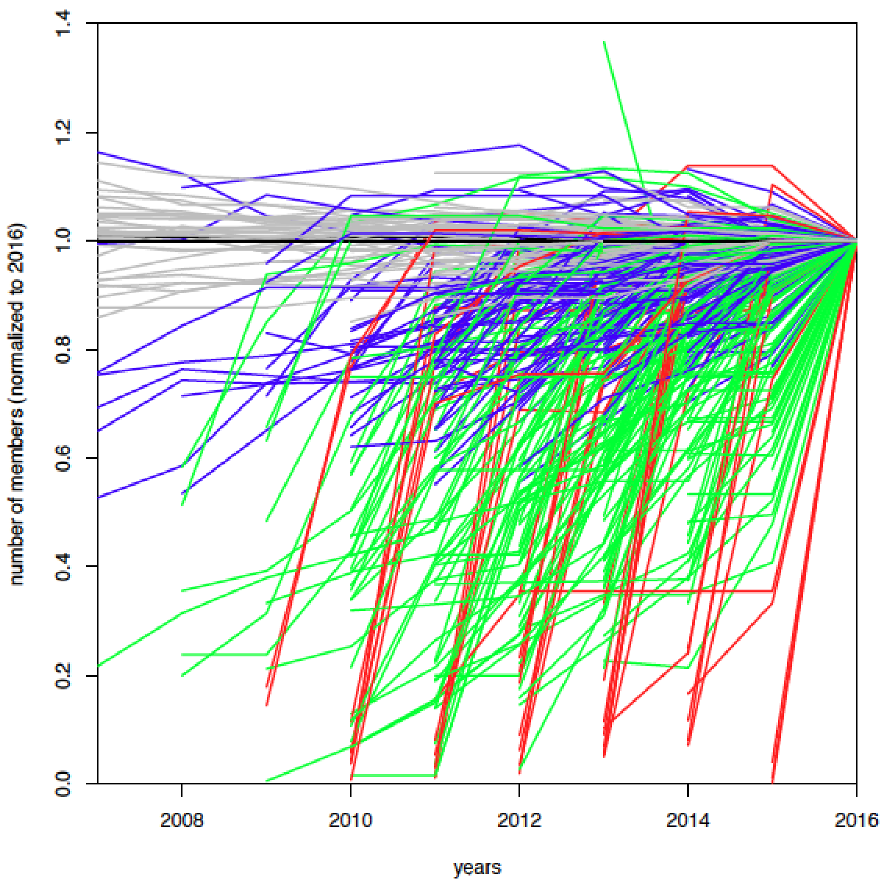

Figure 26 Dynamic patterns of membership among German energy cooperatives. Source: own database building on (Bundesanzeiger Verlag, 2018; Handelsregister.de, 2018)

The number of terminated energy cooperatives amounts to 136 (14%) in our full sample and they are equally distributed over all Federal States of Germany. Analyzing the timing of terminations, we find that most were terminated after 2014, refer to Figure 29. There is a clear response to the change in supportive legislation. With the help of data collected from websites, reports and other sources, we can further shed light on the reasons for the termination. We start with reasons that can be considered as a failure of the cooperatives' purpose. The most common were financial reasons, such as the lack of finances to cover unexpected risks and uncertainties due to unanticipated longer project times, higher costs, or difficulty to acquire projects. Others resigned their activities due to unfavorable legislative changes or the inability to raise enough shareholder capital in the beginning. Management problems also contributed to cooperatives' failure, such as disagreements between and within executive boards and members on the future of the cooperative, lack of management capacities or competences as well as insufficient capacity to adapt to new situations. Finally, some of the terminated cooperatives report problems of public acceptance and also the inability to gain significance. Among the reasons for termination that would not be labeled as unsuccessful are fusions or mergers into enterprises or other legal forms as well as changes in location.

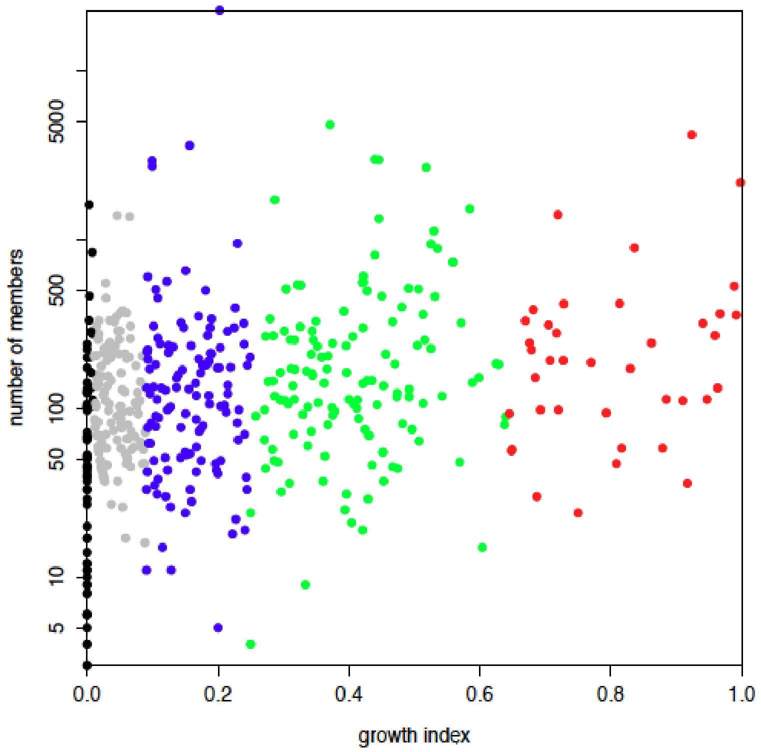

Figure 27 Average rate of increase in membership size versus the size of the cooperative in 2016. Source: own database building on (Bundesanzeiger Verlag, 2018; Handelsregister.de, 2018)

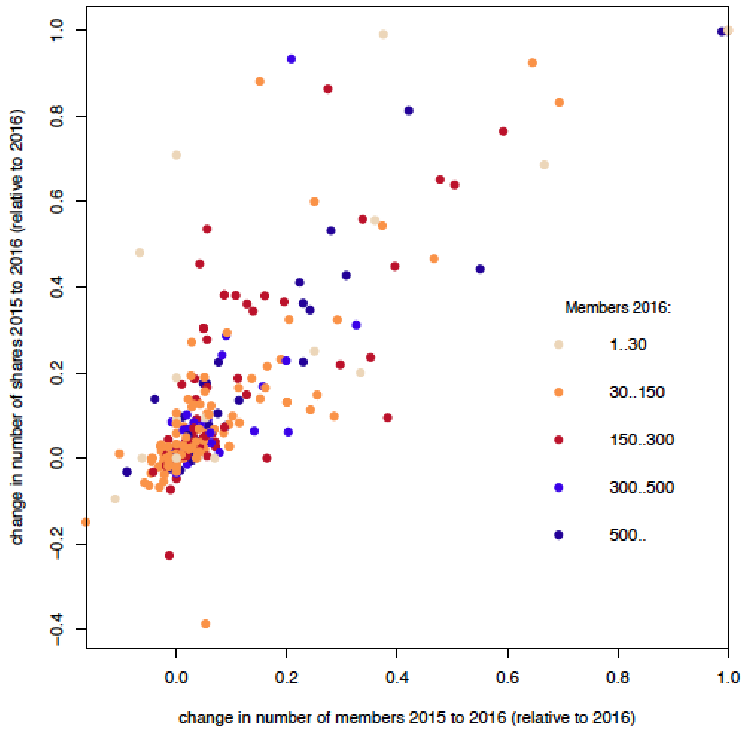

Figure 28 Change in number of members from 2015 to 2016 versus the change in the number of shares during the same period. Source: own database building on (Bundesanzeiger Verlag, 2018; Handelsregister.de, 2018)

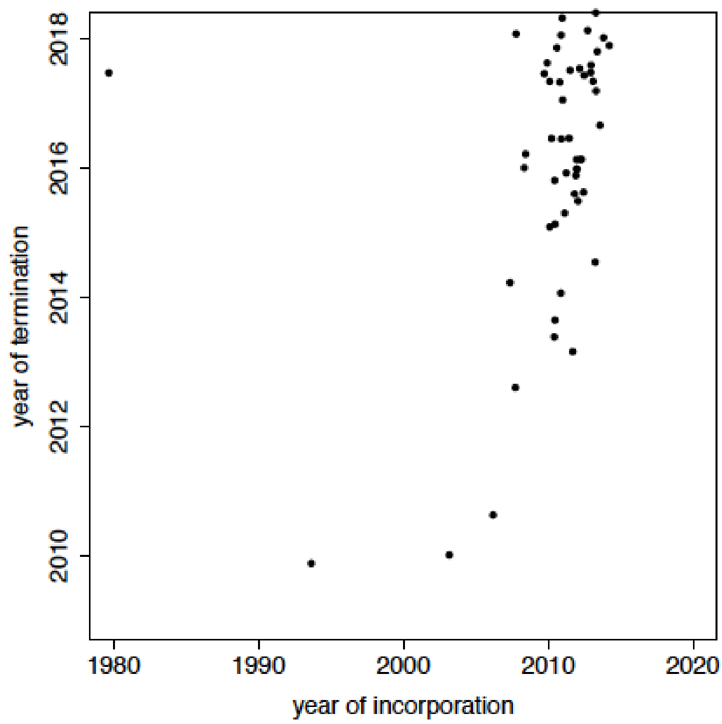

Figure 29 Incorporation dates versus termination dates for closed German cooperatives. Source: Own database building on (Bundesanzeiger Verlag, 2018; Handelsregister.de, 2018)

4.4.4 United Kingdom

Renewable energy technologies were taken up relatively late in the United Kingdom (UK). In 2014, just 19% of electricity were generated from renewable energy technologies. This number is 2.8 times higher in Denmark and 1.4 times in Germany (Curtin et al., 2018). For the scope of this paper, we specifically focus on initiatives that are registered under the Co-operative and Community Benefit Societies Act from 2014 (legislation.gov.uk, 2018). Initiatives founded in earlier years have been reassessed under these new regulations. The majority of the 315 initiatives that we have collected data from engage in solar PV (40%), consulting activities (20%), hydro power (16%), and onshore wind (14%). Of course, the activities may overlap for each cooperative.

In Figure 30, we present the distribution of the year of establishment for these energy cooperatives. Most were founded in the period between 2010 and 2015. The increase in energy cooperatives in the United Kingdom coincides with the introduction of feed-in tariffs (FiT) in 2010 (Hanna, 2017; Nolden, 2013). The UK FiT scheme has been introduced to support the deployment of small-medium scale renewable energy generation (i.e., below 5 MW) in addition to the Renewables Obligation (RO) mainly supporting large-scale generation. It has also been introduced with the aim of allowing distributed generation and empowering people by giving them a direct stake in the transition (Pearce and Slade, 2018). It has made distributed energy projects more profitable with relatively low risk by allowing stable returns on the investments. Energy cooperatives have thus benefited of such favorable energy policy support. In addition to FiT, community energy initiatives have also been benefiting from the Enterprise Investment Scheme and the Seed Enterprise Investment Scheme tax relieves, which allowed investors to reclaim income tax on their investment at the rate of either 30% or 50%, respectively. This additional economic benefit comes on top of the predicted interest rate that investors would receive on the investment. Thus, it also played an important role in encouraging green energy investments in the UK.

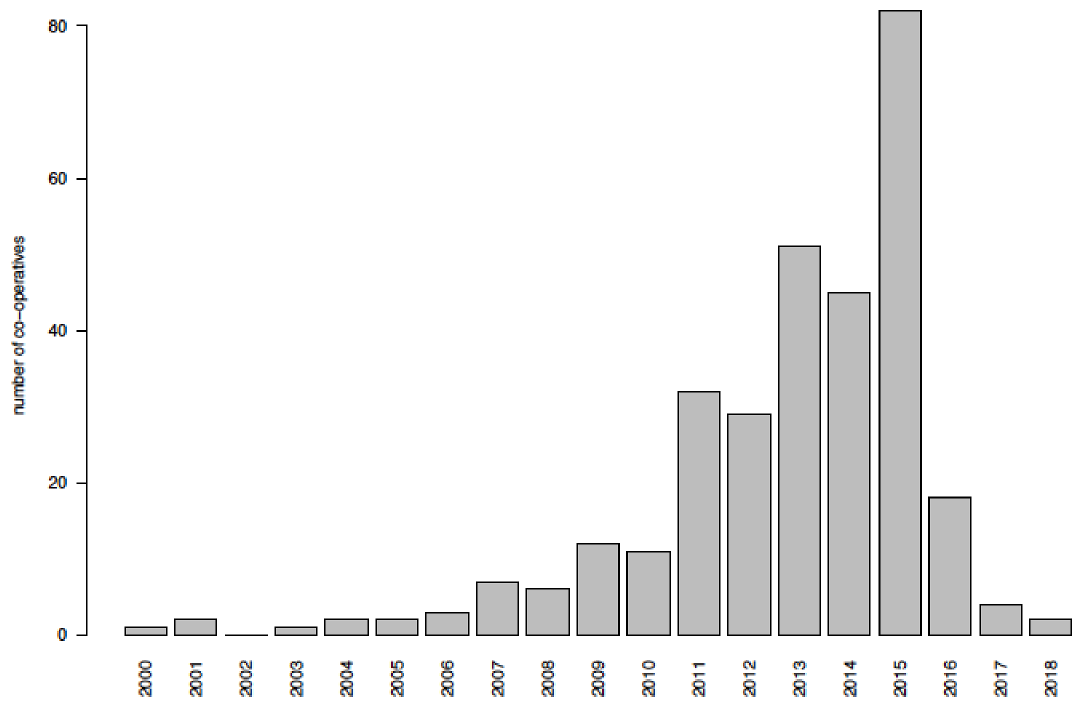

Figure 30 Number of societies newly registered under UK's Co-operative and Community Benefit Societies Act 2014 in a given year. Source of data: own database building on (Financial Conduct Authority, 2018)

Nonetheless, complexity of planning and the lack of finance have been mentioned as inhibiting smaller scales of generation and the growth of community-led schemes [63,66–68] even within the already small scale of the UK FiT (Nolden, 2013). For example, Wales established the Rural Community Energy Fund to provide feasibility grants, while Scotland has the Community and Renewable Energy Scheme, improving access to capital through preferential loan conditions, and England operates the Rural Community Energy Fund (Bauwens et al., 2016; Hall et al., 2016; Hanna, 2017; Scottish Government, 2015). In addition, crowd-funding and community share offers (issued by cooperatives or community benefit societies) have been increasingly used to finance community energy. Crowd-funding escalated since 2015, because individuals can place investments in Individual Savings Accounts to obtain tax-free returns.

Figure 30 shows a spike in 2015 and a rapid decline in the number of newly founded energy cooperatives thereafter. The likely reason for this phenomenon is the change in both FiT and direct policy support to community energy. In 2014, Her Majesty's Treasury announced that both the Enterprise Investment Scheme and the Seed tax relief would be removed from projects that qualify for FiT, RO or the Renewable Heat Incentive (Bauwens et al., 2016). This may have led to a rush in founding energy cooperatives to still benefit from the advantages. Furthermore, in 2016 the FiTs for small-scale installations were drastically reduced and deployment caps introduced, leading to a remarkable reduction in distributed energy installation, in particular solar PV (Pearce and Slade, 2018).

In addition to data on the incorporation (and termination) years of initiatives and their geographical location, our database comprises further details on a subset of entries. 104 cooperatives (33%) provide details on the size of renewable energy installations. They range between a modest solar roof-top installation of 8 kW to 16,300 kW large wind farms. It is interesting to note that hydro power installations are limited by law to 100 kW. Furthermore, the preferred choice of hydro power technology is the Archimedes screw. The argument put forward by cooperatives using this technology is the intention to use the most fish-friendly turbine. A similar preference was found for hydro power projects in Switzerland (Tabi and Wüstenhagen, 2017). The typical size of installations in the small sub-sample is around 200 kW, mainly being larger solar panels. 32 cooperatives (i.e., 10%) also provided information on the number of members, which ranges from 49 to 2260 spiking at around 300 and 700–800 members. Again, in view of the small sample size, this can only serve as an indication of the size of cooperatives. 49 cooperatives (i.e., 15%) published information about the funds raised in order to realize their project. The amounts range from 62,000–3,700,000 GBP concentrating at around 800,000 GBP.

Contrary to the stark decline in the number of energy cooperatives as observed in Denmark, the cancellation rate is comparably small among British energy communities. Out of the 315 initiatives, only 62 (i.e., 20%) have been terminated as of today. Figure 31 shows the number of cooperatives terminated in a given year. A systematic pattern is not obvious from the figure. Instead, the number of closed cooperatives was similar over the years. It can be inferred that changes in the governmental support schemes did not affect the decision to terminate a cooperative, as it has affected the decision to establish one. For 13 of 62 terminated initiatives (i.e., 21%), details about the reasons to terminate activities are available online. The reasons vary from public acceptance issues (Cardigan Community Energy, EasterleyWind Energy, Devon CommunityWind Co-operative), organizational and technical barriers (Kingston Community Energy Limited, Bridport Energy Services), problems to raise enough funds (Abergavenny Community Energy, Mapledurham Community Energy Limited), underestimated demand (Wallingford Community Energy Limited), financial risks due to complexity of planning (Abingdon Hydro), financial problems (Abindgon Hydro, Dove Valley Eco Power Limited), disagreement on purpose or missing focus (Bude Community Power Limited, Wembrook Energy Limited), to changes to other legal forms (Ongarhill Wind Energy Co-operative).

The analysis of the sample from the United Kingdom shows that energy cooperatives registered under the specific act played a role in fostering the introduction of distributed renewable energy in the past years. Therefore, as termination rates are comparably low, future opportunities exist. By mid-2018, the total contribution in terms of installed distributed renewable energy can be estimated from our database to amount to around 150 MW. This is a rough estimate derived by information available from a third of the cooperatives. However, in view of the tendency that mostly larger cooperatives publish such data, we expect this to be a reasonable lower bound. Indeed, it is in the range of data published by Berka and Creamer [20]. The authors report an installed operational capacity of 105MWfor projects run by energy cooperatives and energy trusts in 2014. Bauwens et al. (Bauwens et al., 2016) emphasizes that only 0.3% of UK's generated electricity does not originate from one of the six large utilities. With 303 TWh of electricity produced in 2016, this corresponds to a capacity of 104 MW. This is again of similar size to our estimate.

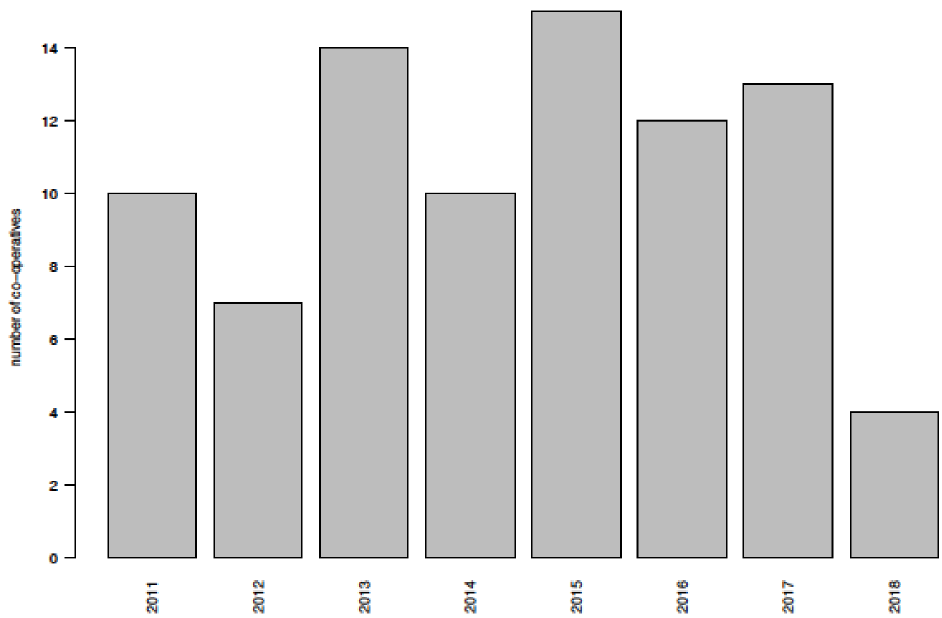

Figure 31 Number of terminated societies registered under UK's Co-operative and Community Benefit Societies Act 2014 in a given year. Source of data: own database building on (Financial Conduct Authority, 2018)

4.4.5 Austria

Austria's electricity system is traditionally based on hydro power. In 1970, around 75% of domestic generation came from hydro power plants. Energy cooperatives were important enablers in rural areas. Our database of Austria contains 9 cooperatives founded during these years and still exist today. The remaining 25% of domestic power generation was supplied by thermal power plants powered by gas, brown coal and oil. Today, hydro power has a share of 36.5% among the renewable energy sources. Similar to other EU countries, the environmental movement in the 1980s and early 1990s was an important positive cultural factor. These groups favored wind and solar energy despite the announcement of the Austrian government to disregard the development of wind energy due to sub-optimal wind yields in the country (Schreuer, 2016).

However, the engagement of communities led to a notable increase in wind power from around 200–600 kW in the mid-1990s to currently around 1000 MW (Windkraft in Österreich, 2014). Experts estimate that around 80% of installed wind power capacity in the mid-1990s in Austria were owned by them. In 2010, collective citizen ownership of wind farms still accounted for around 40–50% of total installed capacity (Schreuer, 2012). Most of the community initiatives active in the wind industry are organized as shareholder societies, or they are collaborating with existing utilities. This particular form is known as the citizen power plant ("Bürgerkraftwerk"). Still, wind energy only makes up 4.8% of renewable energies in Austria.

The second most important renewable fuel after hydro power (having a share of 36.5%) is wood with 29.6% [74]. With Austria being rich in forest land, the country has one of the highest shares for biomass in Europe. This was achieved by a considerable ramping up of biomass-based district heating in the 1990s and 2000s. For example, the number of installed plants increased four-fold from 1999 to 2010 (Meyerhofer Burger, 2011). 45% of the overall district heating output were supplied by these plants (Statistics Austria, n.d.), and cooperatives were an important actor in the scaling up. In 2010, 66 percent of the plants were run by farmers' cooperatives (International Labour Office Cooperatives Unit (COOP), 2013). The role of district heating is likely to further increase in the future. In its Renewable Energy Action Plan submitted to the European Commission, Austria plans to increase district heating by a factor of five. The target is to enable 175 PJ of district heating.

Seiwald (Seiwald, 2014) provides a thorough review about historic developments in the upscaling of district heating. The developments coincide with the evolution in the number of energy cooperatives in Austria contained in our database (see Figure 18). 95% of the registered energy cooperatives are active in the area of district heating, typically run in rural areas. Biomass-based district heating started as a niche in the 1990s by sawmill owners. A ramping up of district heating followed, when farmers seized the opportunity to use residuals from the wood industry to generate additional income. They organized themselves in cooperatives to share financial burdens. These cooperatives were also eligible to receive capital grants and soft loans, allowing to cover of up to 50% of the investment costs (Madlener, 2008). Additionally, the Green Electricity Law, which was introduced in 2002, guaranteed feed-in tariffs for biomass-based electricity generation. This explains the continuous growth in the number of cooperatives shown in Figure 18. However, by 2005 district heating plants were established in many locations without considering basic network connections and local demand. A corrective measure was the introduction of efficiency targets for district heating plants of 60% by the Austrian government in 2006. This resulted in a leveling off in the number of newly founded energy cooperatives in the years after, as seen in Figure 18. From our database, we infer that solar PV is only an emerging activity for energy cooperatives in Austria (see also (Reinsberger and Posch, 2014)).

4.5 Conclusion

For all countries studied, our statistical evidence confirms the importance energy cooperatives play in the transition toward renewable energy systems. An important finding is that the historic development of the number of energy cooperatives coincides with the development of supportive schemes in the different countries. Our quantitative analysis thus confirms the qualitative findings of the eleven cross-country studies briefly summarized in Section 4.2. One of the most important contributing factors to the successful establishment of energy cooperatives is the financial support schemes. In particular, guaranteed feed-in tariffs proved to be most effective. In all countries studied, a removal of the supportive schemes caused a remarkable downturn (or at least slowing down) in the founding of new energy cooperatives. Statistical evidence shows how drastic these developments are. Having over 900 energy cooperatives in its peak time, Denmark has meanwhile lost 88% of the energy cooperatives. In Germany, these developments are less pronounced but the yearly number of newly founded energy cooperatives is continuing to drop. Having access to membership and data on financial shares, we were further able to show, that the quantities react much slower.

We find that the fields of activities of energy cooperatives largely align with the national energy system profiles: wind energy dominates the field of activities for cooperatives in Denmark, biomass-based district heating is most important for cooperatives in forest-rich Austria, while Germany has cooperatives active in many different fields reflecting its diverse energy landscape. The same holds true for the United Kingdom. At the same time, since the investment costs for solar PV are particularly low in recent years, a higher number of cooperatives are engaged in this particular technology (regardless of the country profiles). As a reaction to the removal or tightening up of the incentives schemes, energy cooperatives responded with diversifying their portfolio or increasing the numbers of shares and members, as an alternative to completely terminating all activities. However, there are only very few examples of energy cooperatives with members beyond several thousand. Most energy cooperatives keep their field of activities in the region. This makes them vulnerable to legislative changes that target the optimization of the energy system from the perspective of the national level, shrinking leverage possibilities to adjust. Most importantly, energy cooperatives will have to face fierce competition when corporate actors finally enter the new promising markets, which were only opened by pioneering cooperatives. Larger energy cooperatives may provide a solution to this dilemma. Yet, it is important to keep the minimum financial engagement low enough to ensure the participation of diverse social groups. This also supports the local acceptance for the necessity to transition to low carbon energy systems (Langer et al., 2018; Musall and Kuik, 2011). A stronger tie to social opinion can also break the dominant position of established actors and counteract a revival of non-renewable energies (Gabaldón-Estevan et al., 2018).

While we acknowledge that our statistical analysis is far from being a complete account of activities of energy cooperatives across Europe, we provide a lower estimate justified by analyzing focal countries and well-covered forms of cooperative action in Denmark, Germany, Great Britain and Austria. Furthermore, we shed light into current shortages of systematic reporting and how to design aggregate accounting schemes in the future. Our empirical analysis clearly confirms such a need of systematically measuring the contribution by these important non-commercial actors. The lack of data can be eliminated through collaborative efforts, the establishment of an open source database that is shared within the research community and through the development of a sound method able to fill data gaps with proper estimates. The most promising indicators able to capture the contribution by energy cooperatives (and other forms of decentralized collective and individual action) are: the number of people involved in these organizations, the number of associations founded in different legal forms, the number of finances mobilized, the number of jobs or off-spin companies created, the amount of energy services provided (including the amount of energy saved). We suggest to lend from the idea of accounting for ecosystem services (Costanza et al., 2017) to account for social system services.

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Chapter 5

DIFFERENCES AND CROSS-OVERS AMONG ACTORS WITHIN THE DANISH ENERGY PLANNING PROCESS

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Abstract

This paper builds on the social worlds perspective to address the decision in June 2018 by the Danish coalition to strictly curb the country's onshore wind capacity by 2030 on the ground of repeated complaints against turbines. From this key event, we expand the reflection to contribute to the larger contextual understanding of the socio-technical transition of the energy system: how the issue is framed and the contributions and collaborative understanding between the various actors. The recent evolution of the Danish wind energy sector and its implications for future renewable energy technology (RET) development are explored through interviews conducted with actors of the Danish RET sector, who discuss their views on social acceptance through their varied practical experiences. We first analyse areas where views differ, such as visions of optimality that evolve across the social worlds, and the perception shared by researchers that different languages are spoken across their fields. We also analyse areas of agreement, such as a willingness to collaborate and adapt. From those testimonies, we develop on the remaining language barrier discussed by the participants, researchers in particular, akin to a "structural hole", which we observe is reinforced by the way the actors perceive and construct their identities (and social worlds) based on their activities. To address this persistent context, we conclude on the need for formal knowledge brokering roles to help trans-disciplinary energy-themed projects to move forward.

5.1 INTRODUCTION

Denmark has long been known for its extensive use of its wind resources, yet the problematics linked to community acceptance of Renewable Energy Technology (RET) projects have led the government to adapt its energy policies more drastically than suggested by the European Union (EU) as part of a global push for bidding systems for renewable energy projects. Denmark also plans to curb onshore wind capacity from the current approximate capacity of 4300MW to a ceiling of 1850 MW by 2030 (Danish Coalition, 2018). Consequently energy models had to be capped accordingly to reflect this drastic change, especially those with optimising functions. To explain their decision, Danish authorities referred to the negative impacts the technology is having on communities and property values. Considering national efforts around the world to reduce greenhouse gas emissions, for example, via Intended Nationally Determined Contributions (INDC)s and National Renewable Energy Action Plans (NREAP)s, such a decision sets a negative precedent for countries that are still developing their RET capacity and that have potentially large onshore wind resources. In order to meet the current climate and corresponding RET targets, it is crucial to identify the dynamics at play and strategical ways in which conflicts between the differing views can be reconciled.

The context for this decision is the interaction between RETs and the public, where RETs consist mostly of decentralised technologies but each type displays different physicalities, or "hypersizability" as discussed by Walker and Cass (2007), and ranges of environmental impacts. Due to its relatively low installation and maintenance costs but higher visibility, onshore wind power has undergone a period of rapid development in several countries and has been a greater focus for sociological studies on the subject of community acceptance.

The physical disturbances felt from allegedly poorly sited turbines (Anker and Jørgensen, 2015; Poulsen et al., 2018), for example, have led to a conflict between local communities and large-scale energy plans. Community acceptance dynamics have also been linked to the feeling of place attachment, a perspective in which "local opposition is reconceived as a form of place-protective action, arising when technology projects disrupt pre-existing place attachments and threaten place-related identity processes" (Devine-Wright, 2013b) (see also (Devine-Wright and Howes, 2010; Manzo, 2005)). Conflicts have also been connected to a moral opposition to the practices of large 'non-local' developers earning large benefits but returning limited amounts to areas where their wind farms are located (Walker and Cass, 2007). Finally, beside the visibility of turbines, conflicts have also been linked to developers' actions in response to the fierce competition over remaining promising wind sites (Butler and Neuhoff, 2008). The resulting practices have left some among the communities feeling a lack of procedural justice when facing what are ultimately the local consequences of large-scale national or EU energy plans (Batel and Devine-Wright, 2014; Gross, 2007). For example, the Danish grid operator Energinet reported in 2015 an increase in the number of complaints to the Environment Ministry Naturstyrelsen regarding wind projects, some allegedly filed to slow down projects (direct communication with Energinet).

The recent decision by the Danish government confirms that there is a conflict between top-down modelling methods, based on technical and economic rationalities that encourage onshore wind development (Danish Energy Agency, 2014; Kwon and Østergaard, 2012; Mathiesen et al., 2009), and the community acceptance of such projects – including avenues for expressing local opinions regarding wind projects and other RETs (Aitken et al., 2016). Existing attempts to engage populations on a case by case basis are necessary, but in this new context of community acceptance effectively affecting national plans (McCollum et al., 2017; Nguene et al., 2011; Rivers and Jaccard, 2005), it is worth also exploring methods for addressing general behavioural aspects from the initial stage of energy strategies. Ribeiro et al. (2011) reviewed several studies that address the inclusion of social aspects within energy system planning work and concluded that further discussion is needed to define those social aspects of sustainability development for energy models to be able to include them (Ribeiro et al., 2011). The type of studies reviewed by Ribeiro et al. bring further understanding into socio-technical dynamics and how to include human behaviours and opinions in power planning. However, the studies are in most cases narrowly framed in terms of the participating actors and therefore bring somewhat clustered views.

From that observation, the purpose of our study is to explore the socio-technical controversy surrounding onshore wind in a country still seen by many as a pioneer of the industry and RE policies (Krohn, 2002; Sovacool and Lakshmi Ratan, 2012), and from there contribute to the larger contextual understanding of the socio-technical transition of the energy system: how the issue is framed and the contributions and collaborative understanding between the various actors. This recent energy policy shift in Denmark, coupled with the sharp decrease in the number of cooperatives (Bauwens et al., 2016; Wierling et al., 2018) make Denmark a compelling case study for a thorough exploration of the internal dynamics shaping a national energy system. We address these objectives by interviewing actors at different levels of the renewable energy implementation process, from energy modelling to local implementation of RE projects. By exploring how the different actors frame the issue of social acceptance of RETs and wind projects, we aim to identify to what extent the specific aspects of the issue framing differ and overlap. The overall purpose is to identify potential ways in which the differing perspectives of the various actor groups can be reconciled and even enhanced.

5.2 THEORETICAL FRAMEWORK

To illustrate the environment in which actors of the energy transition are evolving, we build on Clarke and Star's (2008) 'social worlds' framework. Clarke and Star (2008) describe how, through time and events, social worlds evolve, become larger and "crisscrossed with conflicts, different sorts of careers, viewpoints, (and) funding sources." Eventually this growing system of social worlds becomes an arena, defined by what its social worlds still share in terms of "mutual concern and commitment to action".

This approach is particularly adapted to the overall context studied here, the arena of energy transition where numerous actors evolve sharing or opposing views on which technologies are most advantageous for future energy systems, and which support policies are most needed. Using the social worlds framework on this arena is useful as it helps unfold those views, which continually evolve following new governments, policies and technologies. As these landscapes evolve, actors of various social worlds might form new alliances, or on the contrary distance themselves from past allies.

Once several social worlds and dynamics are identified, we build on Burt's notions of bridge and structural hole. Burt (1992) defines a structural hole as the "separation between two non-redundant contacts" who hold different information on a similar topic (Burt, 1992). While the social worlds approach takes a more fluid stance on the way social worlds evolve, split and reconnect, Burt's work on structural holes and bridges is beneficial to address social worlds that have remained distant despite attempts for rapprochement and collaboration.

5.3 CONTEXT AND METHODOLOGY

5.3.1 Implementation process of renewable energy targets

To frame the environment in which the actors of energy transition are evolving, Figure 32 presents a schematisation of the Danish implementation process, from the calculations of targets and energy national plans as per global and national strategies, to their implementation into actual projects as local scale. This process is supported by several actors involved in a broad range of activities.

Recent studies have focused on decision by coalition and have linked it to community acceptance with specific angles, e.g., on territorial stigmatisation in rural Denmark (Rudolph and Kirkegaard, 2018) or on the impacts of a supporting policy on citizens living near near-shore turbines (Johansen and Emborg, 2018), while Hvelplund et al. (2017) focus on policies and new economic incentives.

We adopt a broader focus based on the participants' narratives guided by the themes listed below in section 5.3.2.

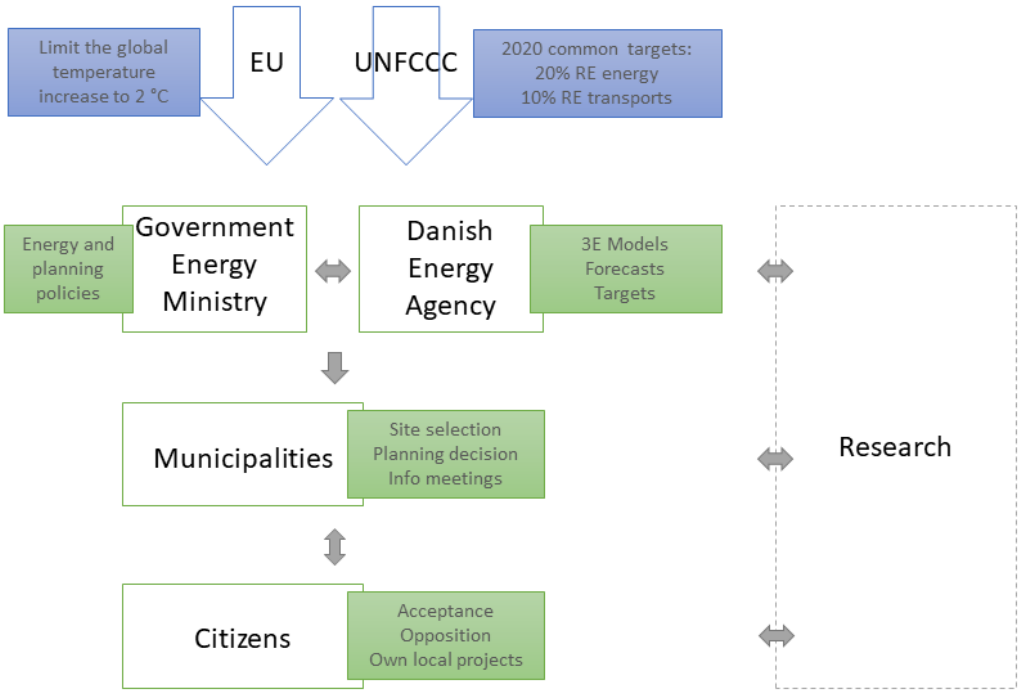

Figure 32 Conceptual representation of the Danish energy planning system

5.3.2 Data collection

To explore how actors across this implementation process frame issues of community acceptance and the means of addressing it, participants with various role and activity at several levels of the process were contacted and invited for interviews. The scope of actors contacted was intentionally broad so as to provide a comprehensive view. Table 12 presents the activities by which the participants are usually identified and whether they work in the public or private sector. To maintain the participant's anonymity, they are mentioned throughout the study using their participant code below, and in some cases the neutral pronoun 'they'.

Based on Søderberg's (2006) methodology on narrative interviews (Søderberg, 2006) and Froschauer and Lueger's "Interviewing experts" (2009) (Froschauer and Lueger, 2009), the participants were interviewed on the themes of: energy policies and evolution of the wind sector in Denmark, social and community acceptance, public involvement, communication between actors and external stakeholders, and were allowed to develop their narratives. The interviews were audio-recorded and lasted from 30 to 70 min. They were then transcribed and iteratively analysed to identify themes and their connections across the participants. The themes thus highlighted were organised in terms of differences and overlaps among the participants' opinions and narratives.

Participant Code	Activity	Public	Private	Length of Interview
A	Energy modelling	x		70
B	Energy modelling		x	60
C	Energy modelling	x		30
D	Energy analysis	x		30
E	Energy analysis	x		60 (with F)
F	Economic analysis	x		60 (with E)
G	Economic analysis	x		40
H	Economic analysis	x		30
I	Develops local energy projects	x	x	70
J	Develops local energy projects		x	50
K	Stakeholder involvement	x		60
L	Stakeholder involvement	x		60
M	Sociology	x		70

Table 12 Description of participants' backgrounds and length of interviews

5.4 Analysis: Differences and overlap

5.4.1 Differences

5.4.1.1 Opinions on the evolution of the Danish wind sector

A difference in scale characterises the interaction relationship between the executive energy agency level at national scale, and the municipalities at the local scale. The municipalities are in charge with enacting energy policies, conducting Environmental Impact Assessments (EIA) and making specific planning decisions (Anker and Jørgensen, 2015). To structure this interaction, a program titled *Strategisk energiplanlægning i kommunerne*[15] developed by the DEA, ran from 2014 to 2016 with the aim of developing strategic planning, i.e., selecting energy technologies best adapted to candidate municipalities. According to all actors interviewed for this study, the project received positive feedback for its aim and proactive stance. It ended as planned in 2016, but local projects running on municipal funding carried on with a similar purpose of strategic planning.

[15] Strategic energy planning in municipalities

However, an interview with a member of a municipal team explained that such workshops also highlight tensions associated with wind energy. Participant K recalled how some participants decided to opt out from the series of workshops to "keep the peace within the community" and avoid further tension with other local citizens and neighbours who strongly opposed wind energy. Participants E and F meanwhile explained that, in certain cases, they had witnessed opposition due to economic inequality: "the amount of money that landowners get from the rent to windfarm developers is growing and regularly reaches about 10% of the project. The neighbours are aware of those amounts and thus know they are getting much less." Participant K added that people opposed to further wind farm development were often louder about their opinions:

- Participant K: "The people who are against [wind power] shout the loudest and the pro wind people are quiet about it."

The workshops also highlighted the lack of faith expressed by "many people" regarding onshore wind energy and the requirements from the DEA for their municipality to identify suitable sites to accommodate new wind farms. In particular, Participant K pointed out the belief among many local citizens that the power to be delivered by the contentious wind turbines would represent only a very small portion of the municipality's electricity demand. Citizens with such beliefs, widespread according to the participant, have been questioning the need to go through such complications locally, i.e. wind site selection, EIA requirements and ultimately hosting the turbines, for such a small share of the total electricity.

This view differs from the public support towards co-operatives that has shaped the image of Denmark internationally with respect to wind energy (e.g., Dillon, 2015; Wierling et al., 2018). This would suggest that the public considered medium-scale (the size that was discussed by Participant K) wind farms positively if they come in the context of a local-based development with an economic return to the community. However, in the 'corporate company' development context, they question the necessity and value of the turbines.

Through these first descriptions we observe a social world of citizens who are unified by their opposition to onshore wind power, although the reasoning behind this opposition ranges from personal experiences of turbine proximity to a more politically-minded rejection of corporate actors' practices.

While some municipalities are thus still in the process of creating strategic planning programs, the new Danish Energy Agreement gave details in June 2018 of the upcoming implementation of a new bidding system for RET projects (Danish Coalition, 2018). This change of decision-making structure was required under EU law (European Commission, 2014) and therefore expected.

However, while EU guidelines included ‘de minimis’ rules that exempted projects including six turbines or less (Kitzing et al., 2016), Denmark has opted to apply it to all future developments (apart from micro-scale). Under this new plan, project developers (for solar PV, onshore and offshore wind) have to compete by bidding for the lowest as possible øre/kWh subsidies, as only the project with the lowest rates and assessed to be feasible will be granted the required subsidies (Danish Coalition, 2018). When questioned about the impact that the change will have on co-operative projects, Participants G and H confirmed that co-operative projects can also still apply, if they can bring their subsidy request to the competitive range. However, when questioned on the same topic, Participant J was quick to point out that the plan is simply taking the possibility of developing local wind sites away from local communities. Participant J’s reasoning is that it is very unlikely that co-operatives will be able to compete with professional large-scale developers, since to øre/kWh subsidy levels are directly linked to the planned capacity, with subsidy rates typically decreasing as the planned capacity increases (Wierling et al., 2018).

- Participant J: “It will stop the local participation completely, because nobody will take part of that. So, the interesting thing is that the government apparently believes that it’s better and more efficient to make the big electricity companies take the contract… if we want to go more into sustainability, then they could say we will achieve the same goals by having a bidding process in some really large wind projects, but [the bidding process] will change the ownership completely and, thereby also, the local participation and acceptance of a wind project.”

This bidding process also marks the end of the Guaranty Fund policy, which granted a starting fund for projects that included a minimum number of local persons among the group of owners. At time of writing and to the best of our knowledge, no other types of similar subsidies in support of local owner are being drafted. Participants G and H stated how the agency had received a “very high number” of applications before the October 2017 final deadline for the use of the policy. This rush to apply before the ending of the fund suggests a concern among wind farm developers with regards to the new scheme and how it will change the dynamics by putting financial competitiveness among the highest prioritized characteristics. This “very high number” and the comments from Participant J above suggest a second social world of actors of the medium-scale wind sector who relied on policy supports, and therefore whose business model is unlikely to allow them to remain competitive within the new Energy Agreement. This social world would include cooperative projects and medium-scale energy developers.

In line with the decision on bidding terms, the new Energy Agreement also revealed the coalition's firm intention to decrease the total number of onshore wind turbines. For that purpose, the agency is planning to take the step of halting supply of new turbines if the planned decrease is not occurring at the required pace. In parallel, the power of the decision on bidding proposals is being centralised to the Energy Agency, which will be in charge during each of the two bidding rounds of ranking the projects and selecting the winning ones.

Despite the multifaceted situation depicted by the research on community acceptance, the main reason cited in the Energy Agreement to explain the decision to halve wind turbine numbers are the inconveniences occurred by citizens on themselves and their properties:

- "The Danish Energy Agency prepares a plan for gradual reduction in the number of wind turbines (…). If the reduction of land wind turbines does not follow the plan, the supply of new wind turbines will be suspended until a sufficient number of land wind turbines have been reduced." Translated from Danish from (Danish Coalition, 2018)

Bearing similarities with citizens deciding to opt-out from workshops to keep the peace with neighbours of opposing views, the new Energy Agreement suggests that political authorities have opted to avoid further complications by definitively moving on from the period of wind co-operatives. This view is shared by many in the energy sector and was directly mentioned by several of the participants, both from the private and public sectors. Thus, it shapes a third social world of politicians and corporate actors who want to move away from medium-scale wind and therefore want to prioritise the few wind developers able to compete for large-scale wind sites.

5.4.1.2 The perception of suboptimality

The positioning of the governing coalition depicted in the new Energy Agreement also connects to a second point of differences observed among our participants: their perceptions of suboptimality.

During the interviews with energy modellers, we questioned them on the perceived need to further develop citizen involvement processes to encourage the modelling of energy projects at local scale. While they all agreed that encouraging stakeholder involvement is a positive action, to some extent, all modellers pointed out that too many individual local projects would pose a serious risk of technical suboptimality at national level:

- Participant A: "The risk is it becomes suboptimal really, they do different things that don't fit together in the bigger system."

Participant A adds that the issue of technical suboptimality is not only linked to local energy developments, but also to a regular abuse by certain municipalities of CO_2 neutrality branding. Participant A explained that as towns rush to improve their energy branding and their claim to being on the path towards carbon neutrality, they prioritise renewable power production but ignore other key elements contributing to the carbon footprint, such as transport:

- "They want to close it around Copenhagen, so they can say now we are CO_2 neutral but of course […] scientifically, you can't say that. But, on a yearly basis you can claim that you are net CO_2 neutral, but you are not a on a daily basis. And then they do nothing about the transport; so, if everybody is doing that, it's not working. So that's where this shows clearly that there's a risk of sub-optimising because of local targets."

In theory, since it is programmed into modelling tools, technical optimality should be a clear enough concept when used in this context of energy models, yet this latest comment highlights how the notion is adapted at energy planning levels to fit a strategic intended image. The consensus on this topic among modellers suggests a fourth social world composed of practitioners of energy modelling, who seek technical optimality through accurate calculations and modelling. They are scientists who reject the shortcuts made in pursuit of a "CO_2 neutral" brand, which justifies adapting the scientific notion of CO_2 neutrality, and consequently running the risk of not addressing decarbonisation in the most comprehensive manner.

Beside these considerations around technical optimality, the decisions expressed by the coalition government in the Energy Agreement relate also to a second form of suboptimality**.** By stating in the Energy Agreement that it is taking actions to improve Danes' average quality of life, allegedly diminished by too many wind turbines, the government takes a stand on what it considers is an optimal life condition.

- "With the decision to reverse the development from onshore wind turbines to offshore wind turbines, account is taken of the experience the Danes have made of nuisances from wind turbines near their homes as well as depreciation of property value.", translated from Danish from (Danish Coalition, 2018, p. 6)

With this statement, the Energy Agreement states that a peak in the number of wind turbines has been reached and frames the past wind-farm expansion and co-operative 'boom' period (Bauwens et al., 2016) as a phase that ultimately has to evolve due to its impact on quality of life. The fracture from this recent past is sharp, while abroad, the image of Denmark as a haven for co-operatives remains still vivid (Dillon, 2015).

Meanwhile, the interviews conducted with social scientists and local RET developers suggest how these two visions of suboptimality come challenged by a third interpretation. Local developers often invest large amounts of time and personal resources to develop their area towards more local self-sufficiency in terms of power, financial and employment, and the view they expressed came at odds from the national and even municipal take on optimality. Participant J described how the prospect of creating several extra jobs locally was an important motivation. Beside the prospect of greater energy security for the area and a reduced carbon footprint, another strong motivation was the feeling of responsibility when considering the trust and investments that neighbours put into this participant's vision and project.

- Participant J: "We would have had a problem explaining why we made people invest in projects that […] [were] not as feasible as predicted."

Thus, for Participant J, daily proximity to the neighbours of the project brings an extra motivational element that differentiates local developments from corporate ventures. Participant J further explained that the topics of climate change or sustainability do not always resonate with local citizens, as compared to prospects of extra jobs and support for the local economy. This description of local optimality also depicts a social world of local energy developers, part of the broader social world of medium-scale wind actors described above, but in this case who maintain a strong link with the area they live in, and who seem to value the well-being of the area as much as their own economic development.

This notion of local optimality was also discussed by social scientists interviewed on their work with communities living near wind farms. They explained how citizens in rural areas often complained how wind farm developers were not able to provide employment, either directly or by supporting local businesses, meaning that people face having to leave their area and relocate in larger cities.

- Participant M: "People are asking even more 'why do they need to put up with these structures and there aren't even any jobs?' What they want is a way to keep communities in the country and if they saw that windfarms are helping with that, then their attitude would probably be different. As it is, it's all pain and no gain."

Participant J also provides advice to other municipalities in Denmark and abroad, and explained how the main concerns that drive those municipalities are, on one hand, the perceived need to improve local consultation and citizens' involvement, and on the other hand, the ongoing concern for creating employment, especially in rural areas. Yet, he expressed disappointment at how some local politicians seem to bow down to pressure from opponents to onshore wind.

- Participant J: "There's a lot of municipalities we're working with, and they are only interested in looking at how do we do an active citizen process, and how do we engage ownership, and how do we create more jobs, and stuff like that. […] but the politicians are afraid of their future as a politician, if they are too much pro wind projects in their own municipality. So, you see some idealistic plans, but when it comes to realisation, then you see very few local municipal plans."

5.4.1.3 Languages and fields of interests

A third difference arising from our interviews relates to the languages used by the different actors, and as such, encapsulates the differing views discussed above. Social scientists have been arguing for further scrutiny of how modelling uses assumptions to describe human behaviours (Jefferson, 2014). When asked about the possibility of including social scientists as part of modelling processes to balance the quantitative/qualitative data input, Participant B pointed out that this topic is an old one and said it comes back "from time to time." According to Participant B, it has now become important again due to a greater societal concern on climate change and the energy transition. He agreed that models need to do better on the matter of inclusion of human behaviours and it represents one of the next big challenges for energy modelling.

- Participant B: "This is an old topic. It depends how much you do believe in this topic. Now it is getting more important because there is less flexibility in the system, there is more involvement in what is happening. So, this is becoming more and more important. A lot of models are lacking on this side. We are really interested in this topic and trying to understand what can be done."

Questioned on the same topic, Participant A expressed regrets that social scientists do not manage to further generalise their knowledge to facilitate collaboration with other fields. Participant A pointed out that there have been attempts at collaboration between modellers and social researchers, e.g., to frame behaviours more comprehensively, but added that the differences in the way the two fields generally work have made this collaboration difficult, and modellers tend to choose to estimate behavioural data themselves in order to carry on with the modelling process.

- "definitely, we could learn from social science more about where to [involve stakeholders and organise participatory processes]. We have tried sometimes, not really successful[ly]. […] If the social science people are not bringing their knowledge up to a more general level that can be used, then the engineers will just do it- because you see a lot of people out here are working with this and taking behaviour and all kinds of things into account without being social scientists but just saying 'okay, this is what we know so let's try to see if we can model it.' And, of course, it would be probably beneficial to have some more insights from social science. But I think that's a really different way of working."

Participant A concluded that behind the issue of understanding each other lies the matter of the language of energy modelling, i.e., numbers.

- Participant A: "We need some numbers. […] So, if they don't come with the numbers then we will create the numbers based on what we can see."

These comments using "we" further describe the social world of modelling practitioners, who as we noted earlier are in pursuit of accurate results, and are therefore willing to be inclusive of other actors to gain the information they lack, such as behavioural data, but only if these data are pre-adapted for their existing tools. Behavioural data describe, for example, levels of a population's willingness to transition to new technologies, and modellers are therefore willing to work on this aspect to make their tools' overall performance at calculating technology timelines more accurate (Gargiulo and Gallachóir, 2013). During the interviews with social scientists, they confirmed the interest that modellers have recently showed for the human dimensions of energy systems, and what social scientists could bring into the equation. In their views, the issue of models' strong reliance on assumptions for human behaviour has always been obvious and they welcomed this realisation:

- Participant M: "The two [multidisciplinary] projects come from a perceived need from engineers: that they're realising that crunching the numbers and building scenarios based on those numbers—no matter how correct the numbers are—ultimately, when you're dealing with people you get a different dynamic coming into play. And they've realised as well, and most of them are quite straightforward about it: they don't regard this as producing accurate predictions or the truth, rather it's a tool for decision makers."

In terms of language, Participant M and L pointed to the limitation of relying on numbers in their ability to express nuances that would allow for a deeper understanding of humans' reactions when faced with a new form of technology, e.g., large-scale onshore wind turbines.

- Participant M: "That was the old attitude about values and behaviours, if you can turn those into ones and zeros, then they would fit nicely into the models. But anything subjective, anything interpretative, anything evaluative, it doesn't fit into the models therefore it is not of any value. That is beginning to shift, slowly."

- Participant L: "These numbers are not unbiased, they are not the truth simply because they are numbers. That can be frustrating, this story being told that because it's a number it's more true than something else. They are a collection of so many assumptions that are in many ways done qualitatively."

During the interviews these comments were associated with several sub-groups of social scientists, such as psychologists, sociologists, anthropologists. Thus, we identify here a social world of social scientists depicted by their frustration with energy modellers' reliance on numerical data, while for them limiting citizen behaviours and opinions to numbers is likely to create a limitation that would impact the value of any conclusion yielded from this simplification.

However, when questioned about the impacts of working language differences, Participant L pointed that, unlike the other participants, they do not believe the issue is linked to languages, but rather to differing interests. In this context, the lack of understanding that the different fields of research mention is linked to a lack of motivation to adapt themselves and their existing work to a different type of activity and language, instead of an inherent difficulty in doing so.

Discussing the interactions they have witnessed between researchers from different backgrounds, Participant L mentioned how they had observed among modellers, particularly young ones, a "group effect" in the sense that some become, to some extent, "obsessed" with the complex Information Technology (IT) tools they are using or learning to use, a level of interest that does not necessarily reflect the usefulness of the results:

- Participant L: "The younger modellers in particular focus primarily on their technical knowledge of the models, but what can we use some of these strange [optimised] results for?"

Reinforcing their earlier comments on an alleged lack of interest for other fields, as opposed to the alleged "language barrier", Participant L believes that this behaviour might be another reason preventing some modellers from opening up to other research methods that do not use similar complex IT tools.

5.4.2 Overlaps

Besides these divergent opinions, the interviews were also analysed to identify overlaps across the opinions and main groups of actors. During the interviews, an element that clearly resonated with all actors is how all share a similar goal of increasing the sustainability of society's power production and are willing to adapt.

5.4.2.1 Adaptation to decentralised energy sources

Most participants expressed how they try to maintain a broad and inclusive approach to their activity. Participant J, who resides in the area they are developing, mentioned how they are trying to address as many aspects of the projects as possible to increase chances of success. They explained how they used both quantitative-based methods, i.e., their own modelling work later complimented by the services of a modelling consultancy, and qualitative-based approaches, such as regular workshops, information meetings and direct interactions with investors and neighbours.

- Participant J: "[Being aware of all aspects of the project] was very important for us, because we were not consultants. We were owners of the project, but our numbers were correct."

Participant I, a second local developer who does not live in the area they are developing, explained how inhabitants of the area have many questions about the systems being equipped in their flats and how, as project leader, Participant I regularly receives numerous requests for information. They are trying to develop innovative ways to address this situation and create knowledge channels, such as an "ambassador citizen" scheme where satisfied clients act as relays with other potential clients for information.

- Participant I: "I think people really underestimate the power of this ambassador mechanism. I mean, if some of these guys sitting there, they're sitting on their veranda and discussing about this cool concept that they've managed to install because they've joined [our project] (…). I think that if we are generous with this, kind of, grab these, kind of, situations, and just give it away as a project, then we gain good will, and we gain these ambassadors, and they will be sitting, and they will convince the other ones sitting on their veranda."

These two comments, alongside the previous support of cooperative windfarms mentioned in section 5.4.1.1, suggest a social world of citizens who are curious of technologies if they perceive that these technologies will have a positive impact for themselves and their community. They also seem to value being kept informed and offered some form of involvement.

Such efforts described by participants I and J to remain inclusive and innovative are also observed at larger spatial scales. At municipal level, we discussed in the previous section the efforts made by certain municipalities to organise workshops, engage with the local populations so that they can express opinions and learn more about ongoing energy projects. While we first discussed those efforts in the context of existing tensions they had highlighted, they have also been reported to yield great results in getting communities more engaged on the topic of energy transition and limiting carbon footprints.

In parallel, groups of neighbouring Danish municipalities have been forming to organise the energy development of their common area in a more organic and joint manner. The advantage is also economic since the common planning office is funded by several municipalities together. According to Participant A, this innovative approach from municipalities is a sign that they are trying to adapt to national policies and a seemingly fluctuating level of involvement on the part of the DEA, and to do so they are bringing down to the local scale some of the decisions that shape their future energy system.

- Participant A: "it's like [municipalities] have been doing a lot, and then there was a stop. And now, it's like moving back, you can see the need to do something on a local level because they are the only ones who can agree where the wind turbines can be put."

The program Strategisk energiplanlægning i kommunerne[16] ran by the DEA from 2014 to 2016, attempted to systematise the planning of sustainable energy resources based on municipalities' land and infrastructure settings. Earlier, in 2009, Denmark launched the Promotion of Renewable Energy Act, which included the "loss of property value" and "option to purchase shares" schemes (Anker and Jørgensen, 2015). Those represented unique attempts to address some of the frustrations that had been expressed by the Danish populations living in the vicinity of wind farms[17]. The new 2018 Energy Agreement (further discussed in section 5.4.1.1) will maintain those two schemes.

5.4.2.2 Common willingness to include varied stakeholders

As mentioned in section 5.4.1.3, the modellers interviewed explained how their field is aware of the limitations still inherent to modelling tools to accurately depict human behaviours. Yet, collaboration attempts have so far not been considered as fruitful as initially hoped, allegedly due to language differences between the fields of research. Aside from these difficulties, they also mentioned some alternative mixed-research ways that have been developed and show some interesting prospects for innovative collaboration.

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[16] Strategic energy planning in municipalities

[17] Beside the positive outcomes, those schemes have also created unique complications, which have been further explored. See for example Johansen & Emborg (2018) about the option to purchase shares (Johansen and Emborg, 2018)

The first example mentioned is a project developed at the University of Geneva, where a team of researchers has been developing a version of the Markal modelling tool called Social Markal. Their approach is to conduct surveys across the population of a selected area and feed the model with the survey behaviour results. According to Participant B it is a promising approach but is extremely time-consuming and would require many more surveys to cover most aspects dealt within the models (Nguene et al., 2011).

The second example described during the interviews is an interface developed with the purpose of facilitating interactions with stakeholders:

- "...if we can make it easier to access our models then we can have some interfaces because it's really difficult to understand what comes out of a model. (…) It depends on how you frame it, you could make it more or less use[r] friendly. Now, the people we are approaching now, they know what [a] megawatt is, but you could have a number of wind parks, you can try to frame it, so it fits to the audience and make it easier; instead of having to put numbers, you could just have some options (high, low, medium), so I think you could take care of that, so you could have kids doing energy planning."

A number of possible combinations are run and saved in advance so that stakeholders are able to modify certain constraints and get instantaneous numerical and graphical overviews of the model calculations. Stakeholders also have the possibility to request data combinations that had not yet been pre-calculated from the interface's website. With this approach, the participant explains they hope to make modelling more accessible to stakeholders, i.e. social worlds, that are not familiar with energy modelling, and therefore increase collaboration without restricting the technical potentials of the model. This is further explored in section 5.5 with the addition of the bridging perspective to supplement the social world approach presented in this section.

5.5 Discussion - Potential ways to bring perspectives together

5.5.1 Structural hole and cooperation without consensus

The overlaps in opinions described in section 5.4.2 demonstrate how the participants and more globally their social worlds share common goals for a successful energy transition. Yet, the differences described in section 5.4.1 point to a remaining gap, or "structural hole", between participants identifying to modelling and social science fields, and whose potential effects on the energy transition call for further investigations. We introduced in section 5.2 the definition by Burt (1992) of a structural hole as the "separation between two non-redundant contacts" (Burt, 1992).

Based on our empirical presented in section 5.4, we address here how this definition applies to the situation portrayed here by energy modellers and social scientists: they are widely knowledgeable about theories and methodologies in their respective fields, but state how they often hit a technical "language barrier" (see section 5.4.1.3) when they attempt to work together.

Participant B indeed described this when they state that they have tried collaborative projects "a few times" but also that those attempts never led to significant results due to communication issues. In the social worlds context, Star (1993) had earlier described a situation of "cooperation without consensus" (Star, 1993) where social worlds are able to "temporarily and contingently" work together when the shared goal is deemed worthy. Following this vision of cooperative work between social worlds, the language barrier discussed by our participants is likely to remain since those individuals from varied professional fields have been able to keep bringing contributions perceived positively within the arena of sustainable transition. Burt (2009) also elaborates that a structural hole can have positive effects in the sense that actors on each 'side' provide benefits to society that are "additive rather than overlapping" (Burt, 2009). Since some form of cooperative work is able to proceed, and actors keep providing their own form of benefits, the barrier is never comprehensively addressed.

Before discussing how to address this alleged language disparity in section 5.5.2, it is useful to further explore what it implies. In the social worlds framework, Clarke & Star (2008) explain that, in an arena, actors will naturally act as representatives of their own social world in comparison to others. This act of representation is usually performed by reinforcing the identity traits known to define the social world (Klapp, 1972). As examples from our case, this is displayed in section 5.4.1.3 by a participant involved in the activity of modelling claiming that *modellers* 'simply' need numbers but social scientists are unable to adapt to this need; similarly, a participant speaking for *social scientists* found it amusing that *modellers* could even attempt to express human behaviours through numbers.

Indeed, this predilection for mathematical representation of the world and for privileging technical and economic epistemologies led Taylor et al. (2014) to argue that the energy models functioned as boundary conditions by imposing the 'discursive spaces' of shared understanding between energy modellers and policy makers (Taylor et al., 2014). Such a boundary condition prevents the social researchers' contribution to larger questions concerning the framing of the energy transition; instead it casts social researchers as specialists, whose role it is to merely provide specific parameter values within the models' pre-defined structures. Our findings show that this boundary condition was particularly poignant in establishing and reinforcing participants' identities in perceived divergent social worlds.

Participant L also said that they observed how *young modellers* in particular seemed to obsess over their modelling tools and show disinterest for other approaches. This behaviour also evokes homophily (the tendency for actors with similar attributes or tasks to be linked together) and how it is known to strengthen bonds within the group and increase introspection (Long et al., 2013; McPherson et al., 2001). This observation is further reinforced by a participant (B) involved with modelling commenting how the issue of excluding social dynamics within the models comes back "from time to time", or another participant's (L) opinion that a lack of interest for other fields, and not a language barrier, is the real issue here (both comments in section 5.4.1.3).

Drawing a parallel with the social world framework is particularly revelatory here, as in highlighting the uniqueness of their group or field as compared to others, these identity reinforcements would function as necessary acts to demonstrate their value and potentially generate career opportunities in relations to addressing climate change as boundary object (Wiener, 1991). Another example in research was given by Tuunainen (2005) who discussed how agronomy researchers in Finland, when put under pressure by their university to collaborate, remained committed to their sub-fields (within the field of agronomy) and yielded results relating to their original research sub-field (Tuunainen, 2005). In such conditions, the structural hole is part of what defines the social worlds on each side, therefore actors are reluctant to see it bridged, as bridging would trigger changes in their identity, their activities and perceived value (Klapp, 1972). These bridging implications explain why the structural hole remains despite the awareness of an existing issue stated by the participants.

The definitions of the structural hole and implications discussed above are particularly adapted to professional groups with types of activities that require different tools, theories and methodologies, such as researchers. However, the participants in our study that were not involved in research activities ascertain their identities in more varied ways and tend to connect to their view of optimality and discourses to it (Strauss, 1978).

Authorities, following a political agenda, express here what they perceive is optimum in terms of what the population wants (see section 5.4.1.2). Thus, while it might be a debateable decision in terms of the energy transition, authorities justify their choice by stating that they listened to the problems expressed by the population. However, the views of what local residents consider optimal address a wide range of themes such as employment possibilities in their area, other local gains from projects (financial and quality of life) (Polèse and Stren, 2000), access to clean energies

(Brundtland et al., 1987), or their personal perception of a technology (Devine-Wright and Howes, 2010).

Thus, while authorities seem to be giving a voice to the population and its concerns, the simplification they use to justify their decision portrays the population as an actor with more simplistic views than those actually expressed (for example, across the interviews completed for this study). The population becomes an "implicated actor" whose association justifies large-scale technological decisions it otherwise cannot comprehensively address (Christensen and Casper, 2000).

5.5.2 Knowledge brokering

The negative effects of the structural hole, which reinforces the separate identities of modellers and social scientists, is a blockage of unique information on each side. Cross-disciplinary projects are important attempts to answer this blockage, but according to our findings, the same issues tend to appear. In such a situation where a pattern of non-understanding seems to be established, the implementation of knowledge brokering roles could be part of the solution. The term is mostly used by network theory to describe actors whose role is to link two sides of a structural hole in creating and maintaining ways for knowledge and information exchange (Burt, 2009; Long et al., 2013). Different terms are used, such as boundary spanners, information brokers, mediators (Cross and Prusak, 2002; Gray, 2008; Tushman, 1977), to reflect the subtle variations the actual function can take. A cultural boundary spanner is used in settings where teams might be speaking different languages or abiding to different cultural norms (Di Marco et al., 2010). While the term "language barrier" is used by our participants, we will use the term 'knowledge broker' to reflect the overall need for knowledge transfer.

From the interviews it also emerged that several of the participants to our study are already filling that role, although without being aware of that particular function or term. The project developers described how they have been adapting themselves to the requests for information coming from other stakeholders of their RET development projects, whether they are about the United Nations Sustainable Development Goals or practical questions about a newly installed smart boiler (see section 5.4.2.1). They explained how the role was not clearly assigned to them, but they perceived that the alternative to them adapting to the task would likely be severe delays in the projects and unsatisfied customers and stakeholders. Thus, having a clear sense of the negative impacts that a blocked knowledge channel could have was in those cases an important motivator.

Concerning energy authorities, all participants from this background stated how the recent projects that aim to adapt energy technology planning guidelines to the actual environment of municipalities[18], thus enhancing knowledge exchange, were received very favourably. Such endeavours created direct channel of information across and between municipal and national levels. Municipal agents who organise consultative workshop with local populations were then able to demonstrate to the citizens participating in the workshops a greater interconnectivity more traditional top-down hierarchy of governmental information flow. The positive feedback on such projects illustrate the benefits of clearly establishing the role of knowledge brokers as part of a project's guidelines, before the need for information arises, thus increasing the chance to avoid frustrations as those discussed in section 5.5.1.

Besides the obvious benefits of enhanced communication (Burt, 2009), several costs or limitations to the role have been identified by the literature and some of those limitations were indeed mentioned across the interviews. Knowledge brokers are at risk of being stressed and overwhelmed by the reliance other stakeholders might develop towards them (Cummings and Cross, 2003). One of the participants (I) involved with developing local projects described how answering requests for information is a normal part of their position, but indeed expressed a slight weariness at being the only point of contact mentioned for the project and wished that a dispatching of requests was better orchestrated among several team members.

A second limitation results from the time constraint that typically applies to the knowledge transferred if no effort is given to maintaining the exchange channel (Burt, 2002). We indeed heard how the "language barrier" remained between researchers despite several projects attempting to mix fields, and the limited knowledge exchange that must have occurred during those projects was not efficiently registered.

Another limitation that is particularly prevalent in the cases we have described here is the matter of trust towards the knowledge broker. Brass et al. (2017) discussed how building and maintaining trusting ties is easier between similar actors (Brass et al., 2017). In our case, the groups with needs for increased communication, i.e. researchers of different fields, national energy authorities and local citizens, have difficulties identifying with each other and therefore the prospect of building trust will remain limited if no localised and informed effort is applied towards it in advance. In such cases, the knowledge broker role is to be aware of how the identity affiliation of the various actors affects the perception of trust.

Knowing these limitations in advance, from both the literature and the recorded experiences of past cross-disciplinary projects, provides opportunities to constructively develop those projects

[18] Strategisk energiplanlægning i kommunerne

that intend to unite groups distinct by their identity-shaping activities and behaviours (i.e., most of cross-disciplinary projects).

Beyond this, our findings suggest that the activities and behaviours themselves are instrumental in fortifying boundary conditions and bolstering distinct social worlds. What is needed then, is a broadening (and perhaps overlapping) of activities so that the structural hole is not as wide a chasm to traverse for the knowledge broker. Metaphorically, closer shores would mean a shorter bridge.

5.6 Conclusion

The portrait of the Danish RET sector painted by these interviews conducted with actors of the Danish energy system is that of a country at a transition point between its cooperative past of medium-scale turbines and a future that seems, for now, based on competition, corporate actors and large-scale turbines. We analysed the participants' areas of agreement, such as a willingness, in theory, to collaborate with other stakeholders and the feeling that everyone has to adapt to the new dynamics involved in the transition, but also areas of differing views, such as visions of optimality that evolve across groups and activities, and the perception shared by researchers that different languages are spoken across social worlds formed around research fields. As those perspectives of what is optimal are ultimately what shapes the transition and how it progresses, the differing ways in which they consider and process the contextualisation and parameterisation of data lead to a structural hole, which in turn reinforces identities and visions of optimality.

As a consequence, actors with research activities linked to wind energy also find themselves at a transition point. The decision by the Danish coalition of curbing onshore wind turbine numbers on the ground of weak community acceptance, means that community acceptance should in effect be considered as a serious constraint to onshore wind development. Those using energy models agree that they need the collaborative work of actors involved in social research if they are to include those qualitative dynamics that shape acceptance, and require a more nuanced approach than conventional quantifiable parameter data can provide. Yet, after years of attempting cross-disciplinary work, working language differences are still reported as a major hindrance to produce real collaborative results. Those persisting difficulties call for a broadening of activities, for practitioners to be exposed earlier to visions of optimality that challenge theirs, supported by formal knowledge brokering roles to initially facilitate the distribution of information between the various activities. Thus, individuals with an awareness of the various working methods and modus operandi, who are also able to progress around the natural tendencies for individuals to prioritise their own social world, would function as knowledge brokering points. By being able to recognise the patterns of self-preservation within social worlds and propose adapted ways to move the collaboration forward, they could build necessary trust among the various actors.

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Chapter 6

DISCUSSION

6.1 SUMMARY OF ARTICLES AND FINDINGS

In the previous four chapters, we explored how matters of social acceptance transpire at several steps and scales of the translational process. In Chapter 2, I presented a review of peer-reviewed energy modelling studies framed by COP15 in 2009 and COP21 in 2015. This review highlighted an increase in the number of, and therefore interest in, such studies. This increase, however, concerns mostly studies at the national scale, while the number of studies at the sub-national scale decreases. In addition, popular tools presented as theoretically adaptable to several geographical scales, such as TIMES or LEAP, are almost always used at the national scale within the sample. Furthermore, a search of keywords linked to social acceptance throughout the sample reveals their very low use and a lack associated discussion. Considering the numerous dynamics linked to human behaviours regarding energy that cannot be comprehensively transcribed at the national scale[19], we cautiously interpreted those findings as indications that the modelling activity is not adapted to support energy transition single-handedly, despite the growing role it is being ascribed. Thus, this chapter highlights the need for further exploration into the consideration given to social acceptance at the other steps of the translation process.

The policy level of the translational process is further explored in Chapter 3, which builds on the existing literature on social acceptance and answers the call by Devine-Wright et al. (2017) for a cross-scalar approach to social acceptance by proposing an analytical framework with this broader approach in mind. The application of this framework to the NREAP policies proposed in 2010 by Denmark, Ireland and the UK provides valuable information regarding how those three wind-rich countries articulated social acceptance as part of their energy policies. The framework analysis reveals the very similar policy profiles presented by those three countries, which are characterised by a heavy focus on the market dimension of social acceptance, at all scales. All policy profiles demonstrate a marked effort to include local businesses and provide them with opportunities to take part in energy transition. The community dimension is generally much less considered, but we observed a stronger focus for local producers and prosumers – a category that we labelled the meso level of the community dimension. By multiplying the connections between this category

[19] Nor is it the case at sub-national scales, but the larger the scale, the more variety of dynamics and, consequently, the more resultant assumptions.

and market-focused incentives, policymakers seem to increase opportunities to create connections with those existing dynamics. We interpret the prevalence of market-related dynamics within those findings to be illustrations of the enduring difficulties for policymakers in addressing qualitative dynamics. The actors of the community dimension that are given the larger focus are those involved in quantifiable activities, such as purchasing energy devices to produce their own decentralised power. From those findings, we conclude that despite the policy trials and varied strategies that those three countries have developed in their efforts to benefit from their wind resources, they have not yet succeeded in developing comprehensive policy answers to the qualitative aspects of social and community acceptance.

The focus on the inclusion of local energy producers within NREAP policies discussed in Chapter 3 is further explored in Chapter 4, where we presented statistical evidence on the activities of energy cooperatives in Denmark, the UK, Germany, and Austria. We observed that, while three of the four countries display a recent slowing in their growing numbers of cooperatives, Denmark has experienced a strong decline since its peak in 1999. At that time, the country hosted more than 900 wind cooperatives with over 150,000 households participating in the scheme. It now counts less than 200 cooperatives, which places it behind Germany, Austria and the UK in terms of energy cooperative numbers. One of the main reasons for this decline is the progressive loss of supporting schemes adapted to cooperatives, and their replacement by incentives encouraging private and corporate ownership. The closure of the feed-in tariff in 2002 left corporate actors with economies of scale that facilitated them in becoming overwhelmingly dominant after entering the already established sector. From those findings on the progressive loss of opportunities for cooperatives, we discussed how their role as enabling actors of the transition – in that they demonstratively built social acceptance for decentralised RE technologies – is not fully understood, or recognised, by the Danish government. The continued development of onshore wind in Denmark now depends on the evolving profitability of the sector with regards to spot markets and future wind power prices.

This recent evolution of the Danish wind sector and its implications for future RE development are further explored in Chapter 5, where we presented the qualitative analysis of interviews conducted with actors of the Danish RE sector selected to represent a range of activities and backgrounds, who discussed their views on social acceptance through practical experiences. We find that local energy project developers deplore the introduction of an ultra-competitive[20] bidding scheme as part of the new Danish Energy Agreement, the structure of which indubitably seems in

[20] The EU guidelines suggest that the bidding system for onshore wind power should apply to projects of six turbines or more. Denmark has decided to apply it to any wind turbine project, apart from micro-turbines.

favour of corporate actors. The analysis also highlighted differing views among actors – such as different visions of optimality across the social worlds[21] shaped by the actors – and researchers, pointing out that they speak different working languages, which impede collaboration. Areas of agreement were also identified, such as a common willingness to collaborate with other actors and stakeholders. From those testimonies, we elaborated on the remaining language barrier discussed by the participants, and researchers in particular, akin to a "*structural hole*". To address this persistent context, we conclude on the need for additional formal knowledge-brokering roles to support trans-disciplinary projects to overcome this alleged barrier and allow actual collaboration.

6.2 KEY FINDINGS

In this section I link the findings from Chapters 2 to 5 (summarised above in section 6.1) to the three issues, presented in section 1.3.1, identified from the energy transition context detailed in section 1.2. These three issues, addressed in sub-section 6.2.1 to 6.2.3 below, are:

- Relevance and top-down planning structures: the need and means for the inclusion of social aspects into power system modelling at the national decision-making scale (Gargiulo and Gallachóir, 2013; Nguene et al., 2011; Ribeiro et al., 2011)
- Policies and measures implemented to address lack of public support: their reach and associated resources
- Analytical framework on social acceptance: the lack of research on interactions between dynamics at the different scales of the energy system (Devine-Wright et al., 2017)

6.2.1 Relevance of top-down energy planning structures

Considering the first issue identified linked to the relevance of top-down energy planning structures, a parallel appears between the findings of Chapter 2 on the increase in the number of modelling studies at the national scale using optimisation tools, and the call for INDCs (globally) and NREAPs (in the EU) to be calculated using similar modelling tools to allow for cross-comparison. This evolution represents a strengthening of the national focus preferred over sub-national focus for modelling studies in both academic and official arenas. This is consistent with the fact that for the first time in COP history countries have agreed on shared objectives, as discussed in Chapter 1, and this increases the need for data cross-comparison. However, we also discuss in Chapter 2 how all modelling tools – be they simulation or optimisation – need to make simplifications to be able to operate at the extended time and scale range we require. More

[21] As per Clarke and Star's (2008) social worlds framework applied in Chapter 5 (Clarke and Star, 2008)

particularly, modellers have been discussing how to improve the simplifications and assumptions required when integrating human behaviours into a modelling database. It is expected that the generalisation and use of big data will partly inform this problematic by delivering behavioural quantified data on a large range of aspects. This approach, however, poses ethical questions that need addressing – for example, regarding who is allowed to access the aggregated data and for what reasons. But this recording of our habits and behaviours has another limitation in that human decisions do not always rely on predictable and objective reasoning.

The actions of citizens gathering support among communities located near RE projects to use their democratic right to register their opposition have been researched for years, but a lack of systematic and quantifiable recording of the impacts of these actions has prevented them from clearly assessing their reach. As such, community acceptance was then mostly discussed in the fields of environmental psychology and related research. Now, the recent decisions by the UK and Denmark to halt or limit their support for onshore wind power, with community acceptance issues cited as their main official reasons, give a more straightforward picture of the impacts that had been building up in the background. Modelling-wise, these decisions negate numerous wind-focused energy pathways that had been proposed over the years, and thus question the relevance of conducting highly complex energy modelling if the outcomes can be dismissed on such grounds.

Technically, this modelling limitation is seemingly a small issue compared to the vast array of complex market dynamics that models are able to compute, yet I argue that in light of the other findings on social and community acceptance presented in this thesis, the significance of the decisions to be made, and the extended time-range any type of energy plans usually stretch on, this limitation represents a weakness that needs comprehensive reflection and action at all levels.

6.2.2 Policies and measures implemented to address lack of public support

Considering the second key issue identified in section 1.3.1, in terms of energy policies, the findings of Chapter 3 present policy profiles for the UK and Denmark that are heavily focused on supporting market dynamics. Furthermore, the policies presented in those 2010 NREAPs as ways to encourage citizens to take part financially in the transition and to produce their own low-carbon energy are progressively being stopped without alternatives being proposed. Overall, the study of the NREAP policies in Chapter 3 revealed very few innovative attempts by policymakers to address the matter of low community acceptance. Yet, this matter is now the official justification for halting support of onshore wind.

On this topic of community-focused policies, the relative maturity of the Danish wind energy sector compared to other countries in Europe and worldwide makes it particularly informative, for it can inform of potential paths for other countries developing their RE sector, which might be influenced by Danish strategies. I discuss below our findings from Chapters 3, 4 and 5 on Denmark's recent evolution, before moving on to more general recommendations.

In Chapter 3, we identified two innovative policies towards community acceptance among NREAP policies: the Danish Option to Purchase Share Scheme (OPSS) for wind farms, and one addressing loss of property value due to wind farms. While assessing the detailed feasibility and outcomes of these policies would require further analysis, the fact that the new 2018 Danish Energy Agreement cites citizens' complaints regarding loss of property value as part of the reasoning for the strict cut in turbine numbers suggests that the policy outcome was not judged positively enough in official circles. Concerning the OPSS policy, unless there is an increase in the radius around wind farms within which the scheme applies, the reduction in the number of wind farms implies that fewer people will have access to the investment potential.

As previously mentioned, Denmark is known for its wind cooperatives and enjoys a persisting image internationally as a role model for a shared RE sector (see, for example, this article in the *Irish Times* from 12/10/2015 [Dillon, 2015]). However, Chapter 4 details how those numbers have fallen sharply and the new Energy Agreement is likely to accelerate the decrease even further. Furthermore, since solar PV is one of the technologies considered by the new Energy Agreement, the prospect of cooperatives developing around that technology is also limited. It remains unclear as to how citizens will be able to participate in the energy transition, if at all. Findings from Chapter 5 on how the new agreement is perceived by local RE developers hint that this move of restraining local participation is likely to have negative impacts on local acceptance of future large-scale wind projects, as households previously involved in energy transition increasingly find themselves excluded from the energy sector they helped develop.

This opinion concurs with the analysis in Chapter 4 on the overall social contribution of cooperatives and their role as enabling actors of the Danish wind sector, which now points to an underestimation on the government's part of how essential cooperatives have been in building social and community acceptance. This notion of an alleged (or deliberate) official underestimation is further supported by the contrast between the motive given in the Energy Agreement and the opinions discussed in Chapter 5 – supported by the literature on community acceptance and wind power (Batel and Devine-Wright, 2015; Haggett, 2010; SLR Consulting et al., 2014; Wolsink, 2007a). In summarising these multiple voices in one negative opinion, the government is portraying the Danish population as a simplified and implicated actor, thus negating the role it played in shaping the wind sector over the past four decades. This underestimation of the role played by engaged citizen actors poses the risk of a greater loss of community acceptance than anticipated.

Thus, the research presented in this thesis, in particular regarding the Danish case discussed above and the British RE sector, points to persistent shortcomings regarding the efforts made by governments and policymakers to build and secure community acceptance for new renewable energy sites. Those cases of wind-rich countries with renewable energy policies developed over several decades help to draw conclusions and warnings for the future of renewable energy in the EU as a whole. These shortcomings have led to an unsustainable situation regarding the translational process where governments rely on energy models, which in principle cannot yet factor in matters of community acceptance, while simultaneously citing failure to secure community acceptance as a reason to halt support for a technology, and decreasing policy opportunities for citizen involvement, known to support community acceptance.

The policy focus on encouraging community acceptance has never been particularly strong, prompting many research studies across Europe to regularly suggest greater consideration. In light of the findings discussed above, it now constitutes even less of a priority in Denmark and the UK despite the two countries' experiences in developing their RE sectors. The conclusion to this recurrent lack of focus is that, in the context of regular political changes, the policy level does not yet seem able to address those social dynamics in a proactive manner. Therefore, in the context of urgency surrounding RE development, I argue that it is now crucial that (1) national policy sets are more thoroughly assessed for their inclusion of the various interactions within energy systems (addressed in section 6.2.3), and (2) that the energy modelling practice evolves to be able to include social-related constraints in energy scenarios (addressed in section 6.3).

6.2.3 Analytical framework for policy inclusion

As third issue in section 1.3.1, this thesis is partly aimed at answering a call by Devine-Wright et al. (2017) to propose novel research work on social acceptance that also includes cross-scalar dynamics (further developed in section 1.3.2.2). This is addressed in Chapter 3, where we presented an analytical framework based on the existing literature (Fournis and Fortin, 2017; Wüstenhagen et al., 2007) and which expands across scales and dimensions of social acceptance. I detail below two different contexts in which the framework can be of use and how it would reinforce the practice of policymaking and planning of energy pathways.

6.2.3.1 Testing of comprehensiveness of policy sets

I mention on numerous occasions through this thesis the large body of research on social and community acceptance of renewable energy. Those authors have made important policy recommendations, notably about community acceptance and the need for a more flexible consideration of the dynamics that influence it (e.g., Batel & Devine-Wright, 2014; Bell et al., 2005; Cowell et al., 2017; Ellis et al., 2009b; Wolsink, 2010). Yet, findings from Chapter 3 suggest that there is still much progress that can be achieved in terms of inclusiveness of qualitative dynamics within energy policy sets. All countries present different political and societal situations, yet the lack of progress showed by countries with experience in RE development demonstrates the need to apply a more detailed framework such as the one we propose in Chapter 3, and which would allow for 'comprehensiveness checks' of running policies. Thus, areas and actors that are not adequately addressed could be highlighted more proactively. Such a framework should use neutral practical terms so that it remains usable across agency departments and allows for cross-sectoral collaboration.

The EU's 2009 RE Directive lists in its annex the basic requirements to guide the formulation of NREAPs. Those requirements focus mainly on means for technology implementation (Council of the European Union, 2009b). If the EU is to take the lead on energy sectors, as far as its Energy Union mandate allows, it is in a position to implement such a detailed framework and to request that countries explain the reasons for not addressing certain areas and actors in their energy pathways and policies. The nature of our democratic systems leads, in most cases, to a change of government every five years or so, which is very often reflected in changes of policy development, implementation and assessment. I briefly discussed in Chapter 1 how, despite the global agreement on climate issues, new governments still alter policies based on conflicting political and economic agendas. The use of a global framework for energy policies could limit, to the extents of the UN and EU mandates, abrupt policy drawbacks.

6.2.3.2 Quantification process for qualitative dynamics

Applying this type of categorising framework can also assist with collaborative research, as Chapters 2 and 5 discussed the relationship between energy modelling and social sciences. This has been discussed in research works before, and merely highlighting the 'gap' once again does not seem fully productive. Yet, findings from Chapter 5 demonstrated that the issue remains prevalent in energy circles and therefore still needs addressing for the various research sectors to gain their full potential through collaboration. I suggest here a potential use of the framework in that context, before discussing this topic further in the next section.

As we attempt to do in the analytical section of Chapter 3, applying a detailed framework to a set of policies, laws, research work, or other ensemble of data allows the association of those data to codified categories, and therefore the quantification of those data as per the different categories presented by the framework. This is not a new process, but its application to more qualitative or text-based data could constitute a first step in finding a middle ground between energy modelling and the research on community acceptance linked to the fields of environmental psychology and sociological work.

6.3 Future research - Importance of knowledge sharing

In line with the last point discussed above in section 6.2.3.2, I conclude by discussing below the topic that has been in the background of all the issues addressed throughout this thesis, the levels of collaboration between actors of the energy transition.

I discussed in Chapter 2 how the level of consideration for social dynamics is low within modelling studies. Thus, for this trans-disciplinary development to happen, there needs to be efforts from researchers involved for the modelling practice to better incorporate those considerations, regardless of the current policy environment. This topic of cross-sectoral collaboration is explored in Chapter 5, and our findings suggest that despite all actors agreeing that modelling needs to be complemented by social science to strengthen its relevance, persistent communication issues remain, often linked to identity reinforcing from the different social worlds (Clarke and Star, 2008).

The findings on the level of consideration for social acceptance and citizen involvement suggest that energy modelling could indeed have a greater role to play, but for this it needs to be able to better compute matters of acceptance as well as other human behavioural trends. Achieving this would make energy modelling a powerful complementary check to policy proposals. Findings from Chapter 5 reveal that actors in energy research, whether involved in modelling or environmental psychology, agree that more collaboration is crucial but is hindered by natural expressions of work identity.

The following schematics summarise the focus areas of the different groups in terms of the scales and methodologies where they operate. The areas marked by dotted lines show activities that expand the traditional areas of activities of the groups. These schematics are derived from the various elements that constitute the thesis. As such, they are not intended as accurate representations but instead as support visualisations of the groups or social worlds and those potentially bridging areas on which knowledge-brokering efforts, discussed in Chapter 5, could first focus.

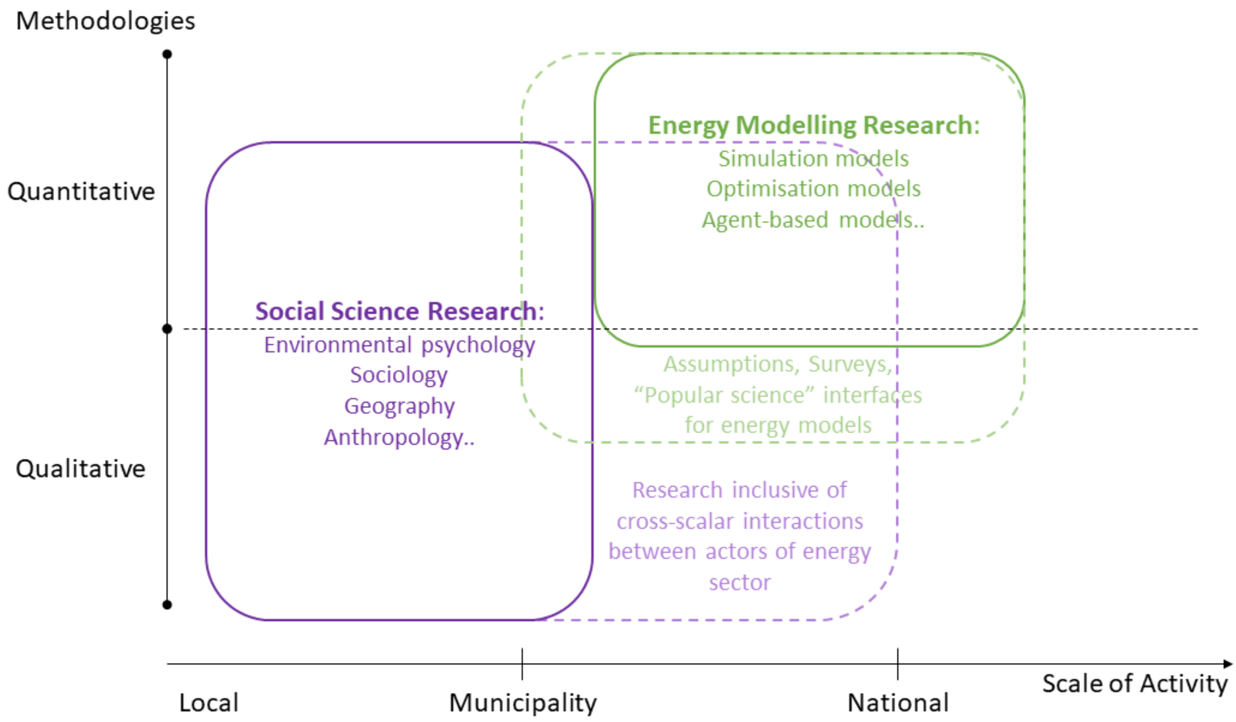

Figure 33 Schematic of collaboration potential for energy research, Source: data presented in Chapters 2 and 5

Previous projects have attempted to enhance collaboration between different bodies of research linked to energy transition, although with limited results according to findings in Chapter 5. The recent push for, on one hand, research on social acceptance to be more inclusive of cross-scalar and cross-sectoral interactions (discussed in section 1.3 as motivation for this thesis), and on the other hand, for an increased involvement of stakeholders through accessible interfaces in energy modelling, is increasing the platform where cooperation is not "*without consensus*" (Clarke and Star, 2008). Figure 33 schematises this opening in terms of the scale of research activity, from local to international, and methods, increasing the amount of 'mixed-research' methods.

Increasing the research focus on the development of user-friendly interfaces for modelling tools, thus unpacking part of the black-box image associated with models, addresses several of the problematics discussed within the thesis. In parallel, research on the inclusion within policies of socially-related dynamics could be further codified for enhanced manageability, as discussed in section 6.2.3.2.

Drafting a similar schematic of collaboration potential for energy authorities, for example in Figure 34 inspired by the case of Denmark, reveals a more intricate profile of potential arenas for methodological developments and induced crossovers between actors and structures. This complexity brings to mind Edgar Morin's position on the "*paradigm of complexity*", introduced in this thesis in section 1.3.3, which would impose a principle of conjunction to complex systems.

Figure 33 and Figure 34 are not accurate pictures, but they illustrate how energy systems cannot be solely separated in distinct entities if we are to cover all scales of development and enhance collaborations.

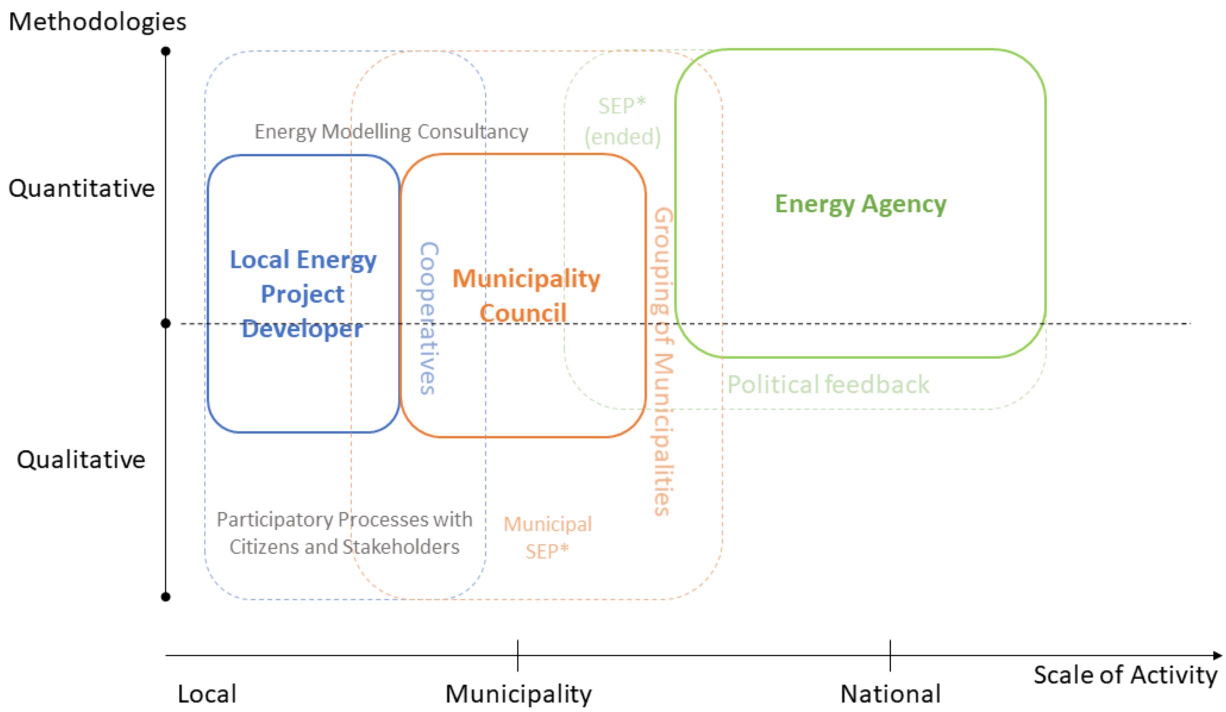

*Figure 34 Schematic of collaboration potential for energy authorities – source: data presented in Chapters 3 and 5, *SEP: Strategisk Energiplanlægning*

6.4 Conclusion

This thesis started within the context of growing opposition to onshore wind power, leading to countries with prominent wind sectors curbing onshore capacity, and the subsequent call for research into social acceptance to broaden and include cross-scalar interactions among market-, regulatory- and community-linked dynamics. The point was not to be blindly pro-wind – a stance that the research on social acceptance has sometimes been accused of taking (Aitken, 2010) – but to explore a situation that could happen with any technology which, despite presenting irrefutable beneficial characteristics with regards to GHG emissions, also happens to alter habitual life conditions. The selected framing for the thesis of a conceptual translational process has allowed us to keep the different steps of the transition in mind throughout, instead of focusing on a single scale or technology. The consequence of such a framing is that the findings might be found lacking in detail in that they are not directly adapted to a particular country or an existing set of policies. Instead, the focus has been to address the matter of energy systems and their relationship to social acceptance as a whole.

Through four articles, the thesis has explored three main issues: the relevance of our current top-down energy planning organisation, the policies and measures implemented to address community acceptance, and the structure of the research on social acceptance. In Chapter 2, we discussed how the modelling step is not yet equipped to include elements that address community acceptance among the constraints identified as influencing energy scenarios. This leaves the policy stage to address community acceptance, but in Chapter 3 we discussed how the NREAP policies presented in answer to the EU Renewable Energy Directive did not address this topic comprehensively in any of our three case-study wind-rich countries. This finding was reinforced by the quantitative analysis carried out in Chapter 4, which led to the observation in the four studied European countries that policies supporting involvement are being terminated, while no clear official record demonstrates the extent to which citizen involvement in energy projects had been supporting acceptance. Due to these limitations, the spatial planning stage dealing with acceptance issues has proceeded on a case-by-case basis.

Those findings combined suggest that the current energy planning system is not equipped to forecast and proactively address a potential reduction of community acceptance for future renewable energy projects. In order to address such deficiencies of policy sets, I argued for a more systematic use of frameworks designed to assess energy policies proposed by governments, to check for their comprehensiveness in addressing all scales and dimensions of energy systems.

Addressing these issues listed in section 1.3.1 led to the identification of a recurrent deficiency in knowledge sharing between energy modellers and researchers addressing community acceptance. Chapter 2 gave a first insight into the low focus put on social aspects within the sample of 287 modelling studies. Chapter 5 explored this with more nuances through interviews of key actors, who expressed their difficulties in collaborating, despite acknowledging the necessity of collaboration to avoid slowing the progress of trans-disciplinary projects (for example, a greater inclusion of community acceptance into energy plans). We discussed in Chapter 5 the reasons for this remaining gap between research fields, and how these reasons need to be overcome for projects to develop greater outcomes that go beyond the objectives of individual research fields. Therefore, I argued that sustainable energy plans and associated projects have an urgent need for formally established knowledge-brokering actors who are able to gather collaborative motivations across fields and coordinate the existing dedication to addressing climate change.

Edgar Morin (2006), whose ideas were first discussed in section 1.3.3 as inspirations for this thesis, defined a system as *"a relation between parts that can be very different from one another and that constitute a whole at the same time organized, organizing, and organizer*". Through my attempt at addressing the framing of social and community acceptance, the thesis has illustrated this complexity that defines energy systems and, through the different discussions, how our efforts to cluster problematics for more clarity have also left out or created others that cannot easily be addressed without further cooperation between different types of expertise. At the national level, recent elections have also shown the limitations of allocating executive powers on sustainability efforts to a single individual or government. Instead, following Morin's definition, we need to accept the complexity in which we are evolving and allocate better-fitting levels of energy governance to dedicated middle actors with actual knowledge of the interactions within our energy systems, who will therefore be able to guide the common effort of consuming more intelligently, of planning ahead with a better collaborative knowledge of potential constraints, and finally, of informing comprehensive policies that reach beyond political agendas.

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